THE JOURNAL OF DENTAL RESEARCH

(Continuing the Journal of the Allied Dental Societies)

A journal of stomatology; devoted to the advancement and dissemination of knowledge pertaining to the teeth and mouth, and to their relations to the body as a whole

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DELAY IN THE PUBLICATION OF THIS VOLUME

The numbers of this Volume were issued during the period from May, 1926, to August, 1927. The reasons for the unavoidable delay have been stated to the subscribers in circular letters. See *This Journal*, Vol. V, p. (3).

DISCONTINUANCE OF THE ABSTRACTS OF THE CONTENTS

Beginning with Volume V, the abstracts of the contents, previously grouped after the table of contents, were discontinued. Less than 2 percent of the number of subscribers have requested their continuance. See *This Journal*, Vol. V, p. (3).

REPORT ON THE ENDOWMENT FUND OF THE JOURNAL OF DENTAL RESEARCH

In order to avoid repetition at short intervals, in view of the prospective issuance of all the numbers of the next volume before the close of 1927, the revised list of contributors to the Fund will be published in the issue for December, 1927.

PROCEEDINGS OF DENTAL SOCIETIES NOW PUBLISHED AS INDEPENDENT JOURNALS WITHIN THE JOURNAL OF DENTAL RESEARCH

Affiliated dental societies now publish their Proceedings on conditions that make each Society's group of papers, in effect, its own independent journal within the *Journal of Dental Research*. Reprints of sections may be obtained for issuance in separate volumes of Transactions. The broad import of this development for the cause of noncommercial journalism in dentistry will become apparent as it evolves in the successive issues.

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GENERAL ANNOUNCEMENTS

Proceedings of Dental Societies to be Published as Independent Journals Within the Journal of Dental Research

Affiliated dental societies now publish their Proceedings on conditions that make each Society's group of papers, in effect, its own independent journal under the covers of the Journal of Dental Research. Sections may be obtained as reprints, for issuance in separate volumes of Transactions. The import of this development, for the cause of independent professional journalism, will become evident in the successive issues. Information regarding the plan will be given immediately to any society that may request it. All communications regarding the contents of the sections should be addressed to the representatives of the respective societies.

Beginning with this volume the papers published by societies will appear in the main body of the text of each number and will not be segregated at the end in a "section of proceedings." The papers contributed by societies in each number will be regularly listed here.

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Delay in the Publication of this Number

The long delay in the publication of the numbers of this volume has been explained in a circular letter to the subscribers. The effort to publish the delayed volumes for 1924 and 1925 has been discontinued. The numbers of this volume will be brought up to date by giving them the combined year numerals 1924-26.

Important Books Received

The dentist's own book. By C. Edmund Kells, D.D.S., F.A.C.D., 1237 Maison Blanche, New Orleans. 1925: pp. 510; 7 5/8 x 4 5/8 in.; $7.50. C. V. Mosby Company, St. Louis, Mo.

The life and work of James Leon Williams. By George Wood Clapp, D.D.S., 220 West 42nd Street, New York City. With an introduction by C. N. Johnson, M.A., D.D.S., F.A.C.D., President of the American Dental Association, 1925: pp. 299; 7 1/4 x 3 3/4 in. Dentists' Supply Company, New York City.

CARIES OF THE TEETH IN OLD-WORLD MONKEYS[1]

SIR FRANK COLYER, K.B.E., F.R.C.S.

London, England

The following notes on caries of the teeth of old-world monkeys have been obtained from an examination of the skulls in the British Museum, the Zoological Society's Collection, the Museum of the Royal College of Surgeons of England, and a private collection. The number of skulls examined was 1,212; of these 795 were classed as from animals in the wild state, 417 from animals in the captive state: in all cases where a doubt existed the specimens have been included in the captive group.

The old-world monkeys belong to the family Cercopithecidæ, which includes twelve genera distributed into two sub-families:

(1) The Cercopithecinæ—the diet is mixed, there are cheek pouches, the stomach is simple; (2) the Semnopithecinæ—the diet is mainly leaves and shoots, there are no cheek pouches, the stomach is sacculated.

Table 1 shows the number of specimens examined of each genus and the incidence of caries.

The percentage of specimens with caries in the wild specimens was 2.2; in the captive specimens, 10.0.

Mr. J. G. Turner[2] found caries in 5.31 per cent of the 433 skulls he examined in the British Museum and in 16.66 per cent of those examined at the Zoological Society's Gardens. The difference between Mr. Turner's results and my own is due to

(1) the division of the British Museum specimens into wild and captive groups;

(2) the inclusion in the captive group of specimens other than those in the Zoological Society's Collection.

[1] Reprinted from the Proceedings of the Royal Society of Medicine, 1924, xvii; Section of Odontology, pp. 11–14.

[2] "Dental Caries from a Clinical Standpoint." Annual Reports, Royal Dental Hospital, 1913.

TABLE 1

	WILD SPECIMENS			CAPTIVE SPECIMENS		
	Number examined.	Number carious	Number of carious teeth	Number examined	Number carious	Number of carious teeth
Sub-family Cercopithecinæ:						
Genus, Macacus	118	3	8	136	14	38
Genus, Cercoebus	11	1	5	18	1	5
Genus, Cercopithecus	216	12	47	150	14	37
Genus, Miopithecus	7			4		
Genus, Erythrocebus	8			24	6	15
Genus, Cynocephalus	66			45	7	23
Genus, Theropithecus				4		
Genus, Cynopithecus	3			6		
Sub-family Semnopithecinæ:						
Genus, Colobus	89	2	2			
Genus, Semnopithecus	259			30		
Genus, Nasalis	14					
Genus, Rhinopithecus	4					
	795	18	62	417	42	118

TABLE 2

	WILD[1]			CAPTIVE[1]		
	Crown cavities	Approximal cavities	Complete destruction of the crown	Crown cavities	Approximal cavities	Complete destruction of the crown
Maxillary teeth:						
I_1		19		2		
I_2						
C						
Pm_1		1	1		2	
Pm_2	1	2		1	2	
M_1	2	2	1	21	9	3
M_2	2			14	1	
M_3		1		12		1
Mandibular teeth:						
I_1		9				
I_2		2				
C						
Pm_1						
Pm_2	1	2	2		1	
M_1	2	4	2	9	5	2
M_2	2		2	6	5	2
M_3	2			16	2	1
	12	42	8	81	27	9

[1] These figures show a marked difference in the position of the carious cavities in the wild and captive specimens.

In *Table 2* is shown the number of individual teeth affected and the position of the carious cavities.

The details of the eighteen wild specimens showing caries are the following:

(1) *Macacus fascicularis*. ♀ B.M. 9.4.1.26. From Pangansaran.

$\underline{|\ M_1}$ complete destruction of crown. It is doubtful if the destruction is solely due to attrition or in part to caries.

$\overline{M_1\ |}$ approximal caries on anterior and posterior aspects. The caries appears to have started at the cervical region. On either side of the tooth there are definite food pockets.

The molar teeth of this specimen show considerable attrition.

(2) *Macacus bintangensis*. B.M. 9.4.1.23. From Bintang Island.

$\underline{|\ M_1}$ mesial aspect. The dentine of the crown is exposed, the attrition being more marked towards the anterior aspect. There are food pockets on either side of the tooth.

$\underline{|\ M_2}$ The anterior portion of the crown surface shows deep attrition with commencing caries.

(3) *Macacus sinicus*. ♀ B.M. 19.6.2.2. Kolagiri, Nilgiris.

Approximal cavities on distal aspects $\underline{M_1\ |\ M_1}$ and distal aspects of $\overline{Pm_2\ |\ Pm_2}$.

In this specimen there is considerable destruction of the alveolar process and much attrition of the teeth. The caries started at the cervical margin.

(4) *Cercocebus collaris*. ♂ B.M. 5.5.23.1. Efulen, Cameroons. The teeth show advanced attrition.

$\underline{M_1\ |\ M_2}\ \overline{M_3\ |}$ caries on occlusal surfaces.

$\overline{M_1\ |}$ anterior root only remains.

$\overline{M_2\ |}$ lost ante-mortem.

(5) *Colobus caudatus*. B.M. 11.4.7.172. Solai, British East Africa.

$\underline{|\ M_1}$ Tooth considerably destroyed. Caries started on cervical margin. Big food pockets in mandible between the second and third molars.

(6) *Colobus* (not classified). B.M. 4.6.2.3. Monrovia (Liberia).

$\underline{|1}$ Caries on palatine aspect, cervical region.

Definite periodontal disease.

(7) *Cercopithecus neglectus*. B.M. 6.11.1.1. Charada Forest, Kaffa.

$\underline{|M_1}$ Internal-palatine aspect destroyed following attrition.

$\underline{|M_3}$ occlusal surface.

$\overline{M_2|}$ commencing caries on occlusal surface.

$\overline{|M_1}$ two roots alone remain.

$\overline{|M_2}$ two roots alone remain.

$\overline{|M_3}$ cavity on lingual aspect.

$\underline{|Pm_2}$ deep cavity on anterior portion of crown surface. The dentine in this region is exposed by attrition.

$\overline{|Pm_2}$ deep cavity on crown surface following attrition.

(8) *Ceropithecus centralis*. ♂ B.M. 13.10.18.4. East of Amala River, British East Africa.

$\overline{M_1|M_1}$ cavity on lingual aspect following attrition.

(9) *Cercopithecus pygerythrus*. ♂ B.M. 6.11.8.1. Coguno, Inhambane.

$\overline{M_1|M_1}$ anterior half of each tooth destroyed by caries.

$\overline{Pm_2|Pm_2}$ roots alone remain of each tooth.

$\underline{I_1|I_1}$ caries on mesial aspects. The caries appears to have started in the cervical region.

(10) *Cercopithecus pygerythrus*. B.M. 6.11.8.4. Coguno, Inhambane.

$\underline{|Pm_1}$ root only.

$\underline{|Pm_2}$ caries on cervical margin.

$\underline{Pm_2\ Pm_1|}$ caries on mesial aspects commencing at cervical margin. Alveolar process around the maxillary second premolars and first molars destroyed.

(11) *Cercopithecus denti*. B.M. 7.1.2.1. Ituri Forest.

$\frac{I_1 \mid \underline{I_1}}{\overline{I_1} \mid I_1}$ Caries on mesial aspects at cervical margin in $\underline{\mid I_1}$ distinctly more marked towards palatine aspect; $\overline{I_1 \mid}$ root only.

(12) *Cercopithecus denti*. B.M. 14.6.2.5. Duye River, 10 miles east of Penghe, Congo Forest. Caries on mesial aspects, all four first incisors.

(13) *Cercopithecus denti*. B.M. 20.10.17.4. Mt. Beni, Semliki Valley, Congo. Caries on mesial aspects of maxillary first and mandibular right first incisors.

(14) *Cercopithecus whitesedii*. ♂ B.M. 11.10.19.2. Nsoli, Bompana, Congo. Caries on mesial aspects of the four first incisors and on distal aspects of the mandibular first incisors. The mandibular left second incisor has been lost post-mortem. The caries seems to be a definite "eating away" of the enamel due to food lodgment. The teeth in this, as in many specimens, are covered with a dark "resinous" material.

(15) *Cercopithecus whitesedii*. ♂ B.M. 11.10.19.3. Nsoli, Bompana, Congo. Caries on mesial aspects of maxillary first incisors.

(16) *Cercopithecus mona*. ♂ B.M. 71.7.8.1. Mt. Cutter, Cameroons. Caries on mesial aspects of first incisors; on distal aspect mandibular left first incisor, and on mesial surface second incisor.

(17) *Cercopithecus petaurista*. ♂ B.M. 11.6.2.1. Bibianaka, Gold Coast. Caries on mesial aspects of maxillary first incisors. The cement between the mandibular incisors shows signs of softening.

(18) *Cercopithecus* (not classified). B.M. 21.3.2.1. Caries on mesial aspects maxillary first incisors.

It is of interest to note that three out of four *C. denti* and two out of four *C. whitesedii* showed caries in the incisor region.

The specimens afford evidence that the caries in these wild animals does not commence in the enamel, but either in the dentine after it is laid bare by attrition, or by portions of enamel flaking off the approximal surface, or in the cement following injury of the periodontal membrane.

The caries in the incisor region is of great interest. Monkeys have a habit of pulling at food with their front teeth and it may be that certain foods are liable to injure the gum margin. The fourteen cases of captive cercopitheques showed thirty-seven carious teeth, the positions of the cavities being as follows: labial surface, two cases; occlusal surface, twenty-nine cases; approximal surface, six cases. In

the teeth showing occlusal cavities the caries had started in the enamel. The captive macaques and baboons show a similar preponderance of occlusal cavities in the carious teeth, the figures being: (a) macaques, twenty-four cases in thirty-eight teeth; (b) baboons, sixteen cases in twenty-three teeth.

The evidence afforded by the specimens shows:

(a) That the Cercopithecinæ are more liable to caries of the teeth than the Semnopithecinæ.

(b) That caries of the teeth is more common in animals kept in captivity than in those living in a free state.

(c) That the type of caries usually seen in captive animals differs from that usually seen in those from the wild state.

11 Queen Anne Street, Cavendish Square, London, W, 1.

THE RELATION OF NASMYTH'S MEMBRANE TO PERIODONTOCLASIA

A Preliminary Report[1]

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A careful study of the predisposing causes of any disease is of the greatest importance. If one could discover the factors which change the character of a tissue or an organ, lessening its resistance so that it easily succumbs to the attack of a special disease, one could find means to combat it even when the exciting cause is unknown or a matter of dispute.

General conditions which produce changes in the gingivae, such as chemical poisoning, gastro-intestinal autointoxication, unbalanced metabolism, deficiency and degenerative diseases, still furnish a wealth of material for study. Local predisposing conditions are of no less importance and there are multitudes of these, causing thermal, mechanical, or chemical injuries opening a door to periodontal infection. In order to show how frequent they are it is only necessary to mention abnormal temperatures of food, the use of sticky food which has the tendency to remain around the teeth and to irritate the marginal gingivae, the volatile oils in tooth-pastes and lotions with their resistance-lowering action, and especially trauma from dental restorations and from various operating and prophylactic procedures. In order to be able to consider the prevention of these local predisposing factors the histological aspects should be studied.

Figure 1 shows that the external surface of the marginal gingiva is lined by stratified squamous epithelium. It is very thick and contains many deep invaginations by connective tissue papillae of the tunica propria. The internal surface of the marginal gingiva forms the outer layer of the gingival crevice, it is also covered by epithelium but of an entirely different nature. If the tooth is just erupting it is extremely thin, without any papillae showing clearly its derivation

[1]Presented at a meeting of the International Association for Dental Research, at the Congress Hotel, Chicago, March 25, 1926.

from the epithelium of the enamel organ. At the gingival crest it has become connected with the external epithelium of the gingiva, and as time goes on it changes its character, becoming stratified and papillated, reverting to the character of the tissue from which it was derived originally. The condition at the base of the gingival crevice, and the manner in which the crevicular epithelium is attached to the tooth, are the special subjects of this article.

The preparation of specimens for the study of the gingival crevice presents certain difficulties. The decalcification necessary to permit the cutting of the bone and tooth tissues with the microtome removes enamel entirely, disturbing the relation of the gingival crevice to the crown of the tooth. The section in *fig. 1* shows a triangular space (*A*) which is caused by the loss of the enamel. Ordinarily, or rather under healthy and normal conditions, the so-called crevicular space is no space at all, the inner surface of the marginal gingiva is in close contact with the tooth surface. Presupposing that the gingiva has its normal tone, it is the function of the ligamentum circulare to prevent the formation of a space. The base of the crevicular epithelium, according to Box (1) and others who have expressed an opinion on the subject, is supposed to be connected with the cementum of the tooth. Box states that imperfect junction with the cementum is frequently observed and that at this place bacterial infection may easily attack the underlying tissue. To study this point I have chosen a cross section through the mandible of a young dog, with the teeth fully erupted. In a dog we have the assurance that the peridental structures have not been disturbed by the use of pumice, toothpastes or scaling. A young animal would be best to show Nasmyth's membrane (enamel cuticle).

In the specimen (*figs. 1–3*) the enamel has been dissolved but Nasmyth's membrane fortunately remained intact, its position alone having been disturbed. A study of the gingival crevice shows (*figs. 2* and *3*) that at its base the epithelium gives attachment to Nasmyth's membrane (*N*), which completes the protective lining of the gingival crevice.

Leigh (2), in an article recently published on the histology of dental caries, refers to the important function of the enamel cuticle or Nasmyth membrane in the protection against dental caries. He points

FIG. 1. PHOTO-MICROGRAPH OF A MANDIBULAR PRE-MOLAR OF A YOUNG DOG. SECTION STAINED WITH HEMATOXYLIN AND EOSIN

A.—Space created by the solution of the enamel. *N.*—Nasmyth's membrane (enamel cuticle). *G.C.*—Gingival crest. *M.G.*—Marginal gingiva. *E.E.*—External epithelium. *C.E.*—Crevicular epithelium. *C.G.*—Cemental gingiva. *A.G.*—Alveolar gingiva. *A.C.*—Alveolar crest. *D.*—Dentine.

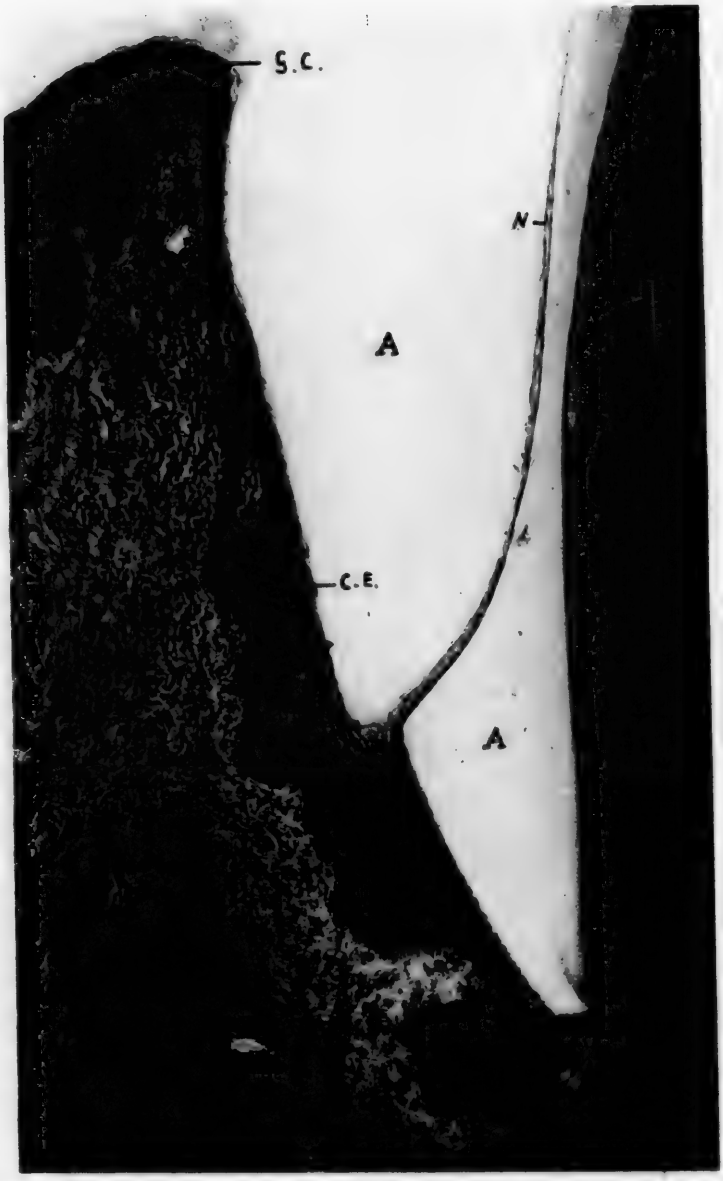

FIG. 2. PHOTO-MICROGRAPH OF A MANDIBULAR PRE-MOLAR OF A YOUNG DOG. SECTION STAINED WITH HEMATOXYLIN AND EOSIN. HIGH MAGNIFICATION

A.—Space created by the solution of the enamel. *N.*—Nasmyth's membrane (enamel cuticle); the membrane collapsed towards the dentine on account of loss of support when the enamel was dissolved. *G.C.*—Gingival crest. *C.E.*—Crevicular epithelium. *D.*—Dentine.

FIG. 3. PHOTO-MICROGRAPH OF A MANDIBULAR PRE-MOLAR OF A YOUNG DOG. SECTION STAINED WITH HEMATOXYLIN AND EOSIN. HIGH MAGNIFICATION

A.—Space created by the solution of the enamel. *N*.—Nasmyth's membrane (enamel cuticle); the membrane was pushed towards the dentine on account of loss of support when the enamel was dissolved. *G.C.*—Gingival crest. *C.E.*—Crevicular epithelium. *D.*—Dentine.

out in a plausible manner that Nasmyth's membrane, although worn off on the occlusal surface by attrition, persists on the remaining surfaces of the crowns of the teeth, protecting them by its resistance to both acids and alkalies. Its preservation therefore is important for the prevention of caries.

From the microscopic study of the gingival crevice it appears that periodontoclasia also may be prevented to a great extent by preserving the crevicular tissue. It seems not at all unlikely that the use of abrasives on the rubber-wheel, brush-wheel, or orangewood stick by the dentist, or on the toothbrush by the patient, may tear away or injure the enamel cuticle under the gum margin, breaking the continuity of the protective membrane lining the gingival crevice. While disease may not follow at once, such injury certainly represents a permanent defect, which leaves a path open to infection. The wisdom of scaling the tooth surfaces with sharp instruments in normal mouths should also receive thought in the light of the presented facts.

In the treatment of children who still have normal peridental tissues, these findings call for a careful consideration and a revision of some of the accepted procedures applied and used for prophylactic measures.

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THE CONTROL OF BLEEDING IN MINOR ORAL SURGERY OPERATIONS

With Records of Two Hundred Coagulation and Bleeding Tests

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INTRODUCTION

Very few patients promptly inform us that they are "bleeders," or, in the recital of their histories, acquaint us with the fact, when such is the case, that several members of their family died from hemorrhage. The slightest injury suffices to occasion fatal bleeding in patients of this kind, for whom all operative procedures must be limited as much as possible, and conducted only if life is in imminent jeopardy. Every case of hemorrhage must be regarded as potentially serious, inasmuch as one can never tell definitely, without preliminary tests, whether the patient has only a marked tendency to bleed or is a true hemophiliac. Very often patients state specifically that they bleed easily. However, dental surgeons do not commonly view such an admission as an indication of a serious possibility.

In this connection the history of a patient as reported by Moral (3) is of interest. The case is that of a 26-year-old clerk who recovered from an attack of typhoid fever at 20, and at 22 was treated for ten weeks for hemorrhages of the stomach. He said that he had repeatedly observed severe bleeding of the gums. The patient observed a pronounced swelling in the lower jaw, coupled with pain in or about a tooth. He consulted a dentist, informing him that he was a "bleeder"—information which his physician asked him to give whenever he consulted a physician or a dentist. Three days after the dentist removed the tooth, the hemorrhage having continued even though ferric-chloride dressings had been applied—a remedy that should not have been used under any circumstances—the patient

was referred to a hospital for further treatment. The man appeared at the hospital pale and undernourished. Blood from the empty alveolus flowed continuously. A tampon made of iodoform gauze was tried unsuccessfully. This was followed by an application of coagulin, both liquid and solid, then Penghawar Djambi, each without result. On the following morning the patient received, intramuscularly, 40 cc. of sterile solution of gelatin; a little later, a 10 cc. solution of sodium chloride intravenously. Notwithstanding these injections and the application of firmly implanted tampons, the bleeding did not cease. At four o'clock in the afternoon of that day, the patient's pulse was 124, and there was increasing pallor. Under ethyl chloride anesthesia the thermocautery was applied. This was successful, with the exception of an oozing from a very small point. The following day, the third in the hospital, the bleeding had been practically arrested, the patient had revived and the pulse rate fell to 108. This condition lasted until the seventh day, but on the eighth day the bleeding increased again, when application of the thermocautery proved effective once more. At intervals, however, the bleeding alternately increased and decreased, the tampon being continuously employed and the patient enjoined to refrain from every unnecessary movement. Gelatin solution was repeatedly injected and locally coagulin and suprarenin applied. Oil of turpentine was employed on the twelfth day. Notwithstanding employment of all the known remedies, the bleeding continued slowly but persistently, the patient was almost white, and the pulse rate rose to 116. After a few days the pulse increased to 138 and the patient's pallor became deathlike. On the seventeenth day vomiting began with the pulse at 120; towards evening the pulse increased. The patient was semi-conscious during the night of the seventheenth day to the eighteenth day, when death occurred after complete exsanguination and visible cerebral convulsions. Similar cases have been reported by Quinlan (5) and others.

Recently, during a lecture before a dental society, a prominent exodontist made the statement that as the offending tooth must be removed, regardless of a patient's condition, he does not bother with tests, but proceeds with the operation. Such indifference cannot be condemned too strongly, This procedure may have been regarded

as good practice some years ago, but cannot be justified in the light of the advancement of modern surgery. To a great many practitioners a test of the blood, insofar as coagulation time and bleeding time are concerned, is a technique that requires test tubes, suction pumps, a well-equipped laboratory, etc. To dispel this delusion the authors present, in a concrete and concise manner, a means whereby every operator, may, in his own office and in a very few minutes, verify or remove his own suspicion or the patient's belief. While the method is not perfect, at least it gives an index that will serve as a guide in determining whether or not premedication is necessary, and in conducting post-operative treatment.

It seems essential, in any discussion of the possible preliminary diagnosis and the prevention or control of hemorrhage, to summarize at the outset the essential factors in blood coagulation and the available methods for the determination of variations or changes from the normal.

Coagulation, according to Howell's theory, is determined by five factors: Prothrombin (*a*), activated by calcium salts (*b*) becomes thrombin, which acts on fibrinogen (*c*) to form fibrin. Prothrombin, which is held in combination with antithrombin (*d*) ordinarily while the blood is in circulation, coming in contact with thromboplastin—thrombokinase—(*e*), found largely in the tissue juices or being partially dependent on the number of disintegrated blood platelets, is allowed to act, due to neutralization of the antithrombin by the thromboplastin.

In clinical work, coagulation time with determinations of the character of the clot, bleeding time, prothrombin time, number of blood platelets, and calcium determination, can be made. As a possible index to detection of post-operative bleeding or hemorrhage, where dangerous capillary oozing is likely, the relative value of these procedures is roughly in this order:

a, *b*, *c*. Coagulation time, bleeding time, and prothrombin time, are valuable. Relatively, prothrombin time and coagulation time tend to agree.

d. Blood platelet count; valuable insofar as purpura may be diagnosed.

e. Determination of blood calcium content is of questionable value.

EXPERIMENTAL

Our study embodied determinations of coagulation time and bleeding time only.

Coagulation Time

For the determination of coagulation time there are several available methods of which the most accurate, tending to obviate some of

FIG. 1. Lancet held in position, just before release of spring

the objectionable features in skin puncture methods (Howell, Lee and White, King and Murray, etc.), are those employing venipuncture. On the other hand, in the type of case upon which this study was made, the convenience of a skin-puncture method or some modification, such as the capillary tube, Biffi-Brooks's, Boggs', Duke's, or Goeckel's procedure, makes it more desirable. It must be con-

stantly kept in mind, however, that with these methods there are certain dangers of serious error, which careful precaution alone can prevent.

FIG. 2. Slide inverted, placing drop of blood in concavity. Shows two views of the process.

Goeckel's (2) method was used. The end of a finger is thoroughly cleansed with alcohol, and punctured with a blood lancet of the type

that operates by the release of a spring, and the time of the appearance of blood is noted (*fig. 1*). A medium-size drop of blood is immediately placed in the center of each of two concavities in a hollow ground slide, which are slightly deeper than those used in microscopic agglutination tests, and a second similar slide is put over it (*figs. 2* and *3*). On tilting the slides gently, about every thirty seconds after the third minute, the noncoagulated blood tends to gravitate toward the lighter area. As coagulation becomes complete, the drop solidi-

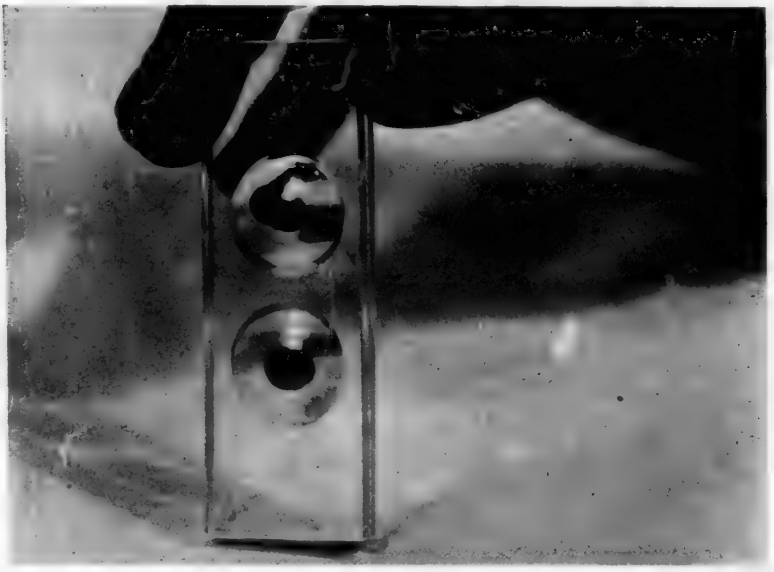

FIG. 3. Slides together, giving relatively air-tight compartments; shows drops of blood, coagulation almost complete.

fies and at times serum exudes from it. When coagulation is complete, the drop can be quickly exposed and the point of a needle touched to the coagulum, which at this time will show shreds of fibrin (*fig. 4*). Final reading is made at this time, which normally is about five minutes after withdrawal of the blood.

Attention should be drawn to the following facts relative to this method:

a. In selecting a part of a finger for puncture, one should avoid areas where the epidermis has been unduly thickened.

b. In order that the flow of blood may be comparatively free, the puncture should be deep (about 2–3 mm.), thereby avoiding pressure on the part and the introduction of thrombokinase or thromboplastin from the tissue juices, which would tend to make the coagulation time artificially short.

c. The slides should be at body temperature, thoroughly clean, free from grease, and dry.

FIG. 4. Coagulation complete, showing coagulum

d. When one slide overlays the other slide, the concavities containing blood should be comparatively air tight.

e. The slides should not be allowed to slip on their surfaces of contact, otherwise the drop of blood would be smeared and the test vitiated.

f. Unnecessary exposure of the blood to the air should be avoided.

g. The method is simple, economical, and relatively accurate.

h. Each blood should be tested in duplicate.

Bleeding Time

Bleeding time is the time required for a small cut to stop bleeding. Duke's (6) method was employed. After thoroughly cleansing with

alcohol the part selected, commonly the tip of a finger or the lobe of an ear, and making sure that the part is dry, puncture is made with a lancet or scalpel, which should be slightly deeper than one used for an ordinary blood count, and the time is noted. At half-minute intervals blot the wound with a piece of absorbent paper (*fig. 5*). Ordinarily bleeding ceases in from one to three minutes, but continuance for about eight minutes may be normal. While the conditions of the punctures should be as nearly uniform as possible (thickness of skin, force and depth of puncture), even deep punctures in normal individuals cease bleeding quickly. Further, in the blotting process, care should be taken to avoid dislodgment of the clot or

FIG. 5. Filter paper, showing drops of blood; bleeding time is normal (first drops used in coagulation test).

squeezing of the punctured part, because the bleeding time would thus tend to be prolonged. One puncture suffices for determinations of both coagulation time and bleeding time.

General Conditions of the Tests

All of our tests were made by a member of the Staff of the Pathological Department in either the Oral Surgery Clinic (Dr. Leo Winter, Chief) or the Exodontia Clinic (Dr. Michael Moss, Chief). Age, sex, previous history as to bleeding, coagulation time, bleeding time, and remarks are given in the accompanying summaries of our data (*Tables 1* and *2*).

TABLE 1

NUMBER	SEX	AGE	COAGULATION TIME		BLEEDING TIME	
			Minutes	Seconds	Minutes	Seconds
1 A[1]	F.	46	7	30	6	00
2 A	M.	32	4	30	3	00
3 A	M.	55	6	00	3	00
4 A	M.	32	4	30	2	30
5 A	M.	16	6	00	4	30
6 A	F.	18	3	00	2	00
7 A	M.	40	4	30	2	30
8 A	M.	23	5	00	3	00
9 A	M.	23	6	00	3	00
10 A	M.	32	4	30	2	00
11 A	F.	14	6	00	4	30
12 A	M.	63	5	00	3	30
13 A	F.	57	5	00	2	30
14 A	F.	38	6	00	5	00
15 A	F.	40	6	00	3	00
16 A	M.	28	5	20	3	20
17 A	M.	32	6	00	1	50
18 A	M.	68	4	30	3	20
19 A	F.	23	4	30	3	00
20 A	M.	15	5	00	4	30
21 A	F.	55	6	30[2]	5	30[2]
22 A	F.	24	6	30	4	30
23 A	F.	16	4	30	2	30
24 A	M.	24	7	00	4	30
25 A	M.	50	5	00	2	30
26 A	M.		5	30	2	30
27 A	M.		4	30	1	20
28 A	F.	34	7	30	3	30
29 A	F.	38	4	00	1	30
30 A	F.	49	4	20	1	20
31 A	F.	59	2	30	2	30
32 A	M.	48	3	00	1	30
33 A	M.	10	4	30	3	00
34 A	F.	50	4	30	2	00
35 A	F.	30	2	20	0	50
36 A	M.	36	5	00	1	50
37 A	M.	47	4	30	2	00
38 A	M.	54	5	20	3	00
39 A	F.	46	4	30	3	30
40 A	M.	15	6	30	2	30
41 A	M.	58	6	20	2	20
42 A	M.	56	4	30	1	20
43 A	M.	56	4	20	1	40

TABLE 1—*Continued*

NUMBER	SEX	AGE	COAGULATION TIME		BLEEDING TIME	
			Minutes	Seconds	Minutes	Seconds
44 A	M.	29	5	00	2	30
45 A	M.	40	4	30	2	00
46 A	F.	41	3	30	1	00
47 A	F.	39	4	00	1	00
48 A	M.	52	4	20	1	40
49 A	M.	11	8	00	4	00
50 A	M.	49	2	20	0	30
51 A	F.	38	7	30	5	00
52 A	M.	47	6	00	3	00
53 A	F.	16	5	00	3	30
54 A	F.	29	4	30[2]	6	00[2]
55 A	F.	39	4	30	3	00
56 A	M.	17	3	00	1	30
57 A	M.	21	6	00	3	30
58 A	F.	39	6	30	5	00
59 A	M.	48	5	00[2]	2	00[2]
60 A	M.	18	4	00	4	00
61 A	M.	53	6	00	2	00
62 A	F.	30	7	30[2]	5	00[2]
63 A	M.	14	5	00	5	30
64 A	F.	36	6	00	2	30
65 A	F.	16	5	00	3	00
66 A	F.	22	6	30	3	20
67 A	M.	35	4	00	2	20
68 A	M.	50	8	00	6	00
69 A	M.	61	5	00	1	30
70 A	F.		4	30	7	00
71 A	F.	28	6	00	2	00
72 A	M.	50	5	30[4]	2	00[4]
74 A	M.	36	5	10	1	20
75 A	F.	25	4	00	2	30
76 A	M.	24	5	30	0	50
77 A	F.	23	7	00	6	10
79 A	M.	40	4	00	0	50
81 A	F.	31	4	00	3	10
82 A	F.	35	4	30	2	30
B[3]			3	30	2	30
83 A	M.	45	5	50	1	30
B			4	30	2	00
84 A	M.	40	5	00	2	20
B			5	10	2	00
85 A	F.	32	4	00	1	10
B			4	00	1	20

TABLE 1—*Continued*

NUMBER	SEX	AGE	COAGULATION TIME		BLEEDING TIME	
			Minutes	Seconds	Minutes	Seconds
86 A	F.	32	5	30	2	30
B			5	30	2	00
87 A	F.	27	3	30[4]	3	00[4]
B			4	00	2	30
88 A	M.	35	4	30	1	10
B			5	00	1	20
89 A	M.	60	5	00	1	10
B			4	30	1	10
90 A	F.	35	5	20	1	50
B			5	20	1	30
91 A	M.	33	5	00	1	50
B			5	00	2	00
92 A	F.	22	5	00	3	10
B			5	30	2	40
93 A	M.	50	5	30	2	00
B			5	20	1	00
94 A	M.	36	5	30	3	00
B			5	30	2	00
95 A	M.	37	5	00[8]	2	50[8]
B			4	30	2	00
96 A	F.	36	6	00	2	30
B			3	30	2	00
97 A	M.	32	7	00	2	30
B			5	30	1	30
98 A	F.	48	5	00	4	00
B			5	00	3	50
99 A	M.	32	4	00	2	00
B			4	00	3	00[7]
100 A	F.	27	4	30	2	30
B			4	20	1	20
101 A	M.	35	4	30	2	00
B			5	00	1	30
102 A	F.	19	5	30	2	50
B			5	00	2	30
103 A	F.	47	4	10	2	10
B			4	00	1	20
104 A	F.	35	4	30	2	30
B			4	00	2	00
105 A	F.	27	4	20	3	20
B			4	30	2	30
106 A	F.	34	3	40	1	50
B			4	00	1	30
107 A	F.	46	6	00	2	40
B			6	00	3	00

TABLE 1—*Continued*

NUMBER	SEX	AGE	COAGULATION TIME		BLEEDING TIME	
			Minutes	Seconds	Minutes	Seconds
108 A	F.	26	7	00	7	30
B			4	30	3	00
109 A	F.	19	4	00	2	10
B			3	50	1	50
110 A	F.	43	5	00	3	30
B			4	30	1	30
111 A	M.	73	4	00	2	00
B			4	30	2	00
112 A	F.	40	5	00	3	30
B			3	30	1	10
113 A	F.	30	4	20	2	00
B			4	10	1	40
114 A	F.	18	6	00	1	30
B			3	00	1	00
115 A	F.	42	5	40	2	20
B			4	30	2	00
116 A	F.	45	3	00	2	00
B			3	10	2	00
117 A	F.	45	4	30	2	40
B			4	30	1	10
118 A	M.	30			0	30
B					0	20
119 A	F.	38	3	00	1	30
B			3	30	1	30
120 A	M.	36	4	30	3	00
B			4	30	2	40
121 A	F.	50	4	50	2	10
B			5	10	2	10
122 A	F.	33	4	00	2	30
B			4	00	1	30
123 A	F.	35	4	00	1	30
B			4	00	1	30
124 A	M.	52	4	00	3	40
B			4	00	2	10
125 A	F.	50	4	30	1	40
B			5	00	1	10
126 A	F.		4	00	1	40
B			4	10	1	40
127 A	F.	30	4	10	2	40
B			4	30	2	00
128 A	M.	37	3	10	3	20
B			3	30	2	00
130 A	F.	13	4	30	2	10
B			4	00	1	40

TABLE 1—*Concluded*

NUMBER	SEX	AGE	COAGULATION TIME		BLEEDING TIME	
			Minutes	Seconds	Minutes	Seconds
131 A	F.	22	3	30	2	30
B			4	10	1	10
132 A	M.		4	00	1	30
B			4	40	1	50
133 A	F.		4	30	2	10
B			4	00	1	30
134 A	M.	25	2	10	1	10
B			3	20	0	50
135 A	M.	76	5	30	2	10
B			5	10	1	00
136 A	F.		5	00	1	50
B			4	50	0	50

[1] "A" throughout signifies tests that were made previous to injection with novocaine-suprarenin (2 per cent solution).

[2] Bled following a previous extraction.

[3] Bled following wound of a foot.

[4] Doubtful history as to previous bleeding.

[5] "B" throughout signifies tests that were made following novocaine-suprarenin injection (2 per cent).

[6] History of nose bleeds (epistaxes).

[7] The skin puncture was deeper than that of the routine procedure.

There were fifty-five cases in this series of tests, which were made before and after local anesthesia with novocain and suprarenin,[1] either by the conduction or the infiltration method. The tests under infiltration anesthesia were made immediately after injection; those under conduction anesthesia, twelve to twenty minutes after injection.

Summary of the results shown in table 1

a. One hundred and thirty-four cases pre-operative, prior to in-

[1] Suprarenin is a synthetically prepared epinephrine and is to be preferred for its many advantages over a product derived from adrenal gland. Its synthesis is carefully controlled at each stage and involves the use of chemicals of stipulated composition; it is a pure, stable, and uniform product, exhibiting the highest degree of physiologic activity. Natural epinephrine, on the other hand, being produced from enormous quantities of adrenal glands of varied strength and origin, is likely to contain impurities, which are inherent in the composition of the glands and in the process of manufacture. The use of Suprarenin solution (1:1000) commends itself for its constancy of action and for its stability. Suprarenin acts by contracting the blood vessels.

jection, had an average coagulation time of 4:54 and a bleeding time of 2:35.

b. Fifty-five cases pre-operative, before and after injection, had an average pre-injection coagulation time of 4:33 and a bleeding time of 2:32; also an average post-injection coagulation time of 4:22 and a bleeding time of 1:45.

c. The coagulation time was practically unchanged by the injections.

TABLE 2

NUMBER	DATE	SEX	AGE	COAGULATION TIME		BLEEDING TIME	
				Minutes	Seconds	Minutes	Seconds
	1925						
73 A[1]	November 30	F.	39	9	30	12	30
B[2]				5	00	1	50
A	December 9			5	40	2	10
137 A		M.	30	4	00	4	30
B				4	20	12	30[3]
138 A	November 9	M.	26	5	30	2	50
B	November 10			5	30	3	00
139 B	October 29	M.	36	5	30	2	10
B	November 2			4	00	4	30
A	November 3			6	00	4	00
80 A	October 22	M.	23	7	00[4]	10	00[4,5]
B	October 23			8	00	7	30[5]

[1] "A" throughout signifies tests that were made previous to injection with novocaine-suprarenin solution (2 per cent).

[2] "B" throughout signifies tests that were made after injection with novocaine-suprarenin solution (2 per cent).

[3] No postoperative bleeding. No bleeding following dental operation.

[4] Bled intermittently for two weeks: after tooth extraction some time previously. This bleeding, the patient said, was "on and off" for two weeks after the extraction.

[5] Almost stopped at 2 minutes.

d. The bleeding time following injection was shortened. The lack of effect on the coagulation time and the shortening of the bleeding time, after injection of suprarenin, accord with the fact shown by Dale and Richards (1) that adrenalin causes a vasoconstriction and a capillary dilatation.

The cases indicated in *Table 2* show special features worthy of comment.

Summary of the Results Shown in Table 2

a. Cases 73 and 137 are marked exceptions to the general rule, case 73 showing check. These cases did not show post-operative bleeding and no explanation is offered.

b. The tests on cases 73, 80, 138, and 139 were made on different days.

c. Cast 80 showed slight adventitious bleeding, which was controlled after the removal of the packing on a return visit after the operation.

CONCLUSIONS AND COMMENT

The average coagulation time in this series is 4:54, and the bleeding time is 2:35. Normal figures have been recorded by various authorities as 4 to 10 minutes and 1 to 5 minutes, respectively. A variation of a few minutes is of practically no significance, however. When abnormal variations occur, ordinarily, the tests can be easily checked; and if "times" are unusually prolonged, treatment is indicated.

So far as we know, none of the cases on whom these coagulation and bleeding tests were made showed post-operative hemorrhage.

Todd (6) and others agree that tests of coagulation and bleeding times are indicated in all operations where oozing is liable to arise, as in jaundiced patients, and tonsillectomies. We venture to add, in *routine oral work*.

The injection of suprarenin may play a part in the prevention of post-operative hemorrhage.

This we believe is the first time that attention has been called to the desirability of these procedures in dentistry.

While true hemophilia is not common, is inherited, and is confined to males, cases of adventitious bleeding due to other causes occur occasionally. Therefore, while it may be necessary to make thousands of tests before one of these cases is found, it is well worth the effort if the consequences of unexpected hemorrhage can be forestalled or avoided.

In cases of prolonged coagulation time or bleeding time, the necessary premedication will depend upon their variation from the normal and the clinical diagnoses of the respective cases. Thus it may be

calcium chloride, 10–20 grains, three times a day, taken three days prior to operation; sodium citrate, etc. In keeping with the work of Partsch (4), if an operation on a "bleeder" can not be avoided, it is advisable, 24 hours before the operation, to inject 20 cc. of horse serum or diphtheria antitoxin in the skin of the back. In hemorrhagic diatheses blood transfusions, x-ray treatment of the bone marrow, and, for severe cases, extirpation of the spleen, may be considered.

Hemorrhage following an oral operation is a very important complication, and one which requires prompt treatment. Hemorrhage may occur in patients not predisposed to a hemorrhagic diathesis; in anemias, jaundiced patients, etc.

Hemorrhage is generally divided into three stages, namely; primary, intermediate, and secondary. Primary hemorrhage is that which occurs at the time of the operation. Intermediate hemorrhage is bleeding that recurs within twenty-four hours of the operation. Secondary hemorrhage is bleeding that takes place after a lapse of twenty-four hours. In several cases treated in the Oral Surgery Clinic, secondary hemorrhage has occurred five to seven days following operation.

The treatment of primary hemorrhage is not of serious importance. If it is at all persistent, pressure should be applied by means of sterile gauze sponges, or pads. If the bleeding is from the alveolus, it should be packed with iodoform gauze (5 per cent). Frequent rinsing of the mouth does not diminish bleeding, but tends rather to stimulate it. Patients should not be dismissed until all bleeding has ceased, and before leaving the office should be instructed in the emergency treatment to be instituted until medical aid arrives. It is good procedure to give the patient some gauze sponges, which can be utilized should an emergency arise while he is in transit.

Intermediate and secondary hemorrhage are more serious, and require heroic treatment. In our experience in oral surgery these conditions always set in at night. When these cases are first seen, the patient is usually unable to talk due to the presence in the mouth of large masses of coagulated blood. Relatives or friends who may accompany the patient generally give a history of refusals of various dental surgeons to offer treatment, some patients even making the statement that entrance into offices was refused by attendants.

The dental surgeon may fear, in such instances, that the patient is a hemophiliac and, not being responsible for the operation, does not desire to be involved in the consequences. The fact remains, however, that we are called upon to treat such cases, and, as they are the results of our own operations, we should be more competent to deal with them than the average medical practitioner into whose hands they frequently pass.

Four essential procedures should be followed in the treatment of intermediate or secondary hemorrhage: (*a*) wash; (*b*) localize; (*c*) cleanse; (*d*) compress. Equal parts of hydrogen peroxide and water, as hot as the patient can bear, should be used by means of a water syringe, and the mouth irrigated, thereby removing all clots. By carrying out this technique the bleeding can be controlled for a sufficient length of time to localize it. If the bleeding is from the mucous membrane, search should be made for any small vessels that may be the cause of it, and if found they should be twisted or compressed. If a vessel is only partially divided, it should be completely severed, as this will probably allow contraction to take place. This method will be found extremely useful in controlling secondary hemorrhage following the removal of growths in the upper jaw. If the bleeding is capillary in character, a pad or sponge of a sterile gauze applied with firm pressure is usually sufficient to stop it.

When the bleeding is from the alveolus, the following procedure is effective. An injection of novocain-suprarenin is made in the strength of 1.5 per cent for the maxilla and 2 per cent for the mandible. The socket is thoroughly cleansed, with the aid of a curette. A strip of sterile gauze two inches long and an inch or one-half inch in width, saturated with suprarenin is inserted into the socket, and over this iodoform gauze is packed as firmly as possible. A pad of gauze is put over the socket, upon which there is placed a saddle of modelling compound, and a Barton bandage (*fig. 7*) is applied to maintain the pressure. The saddle is prepared by taking a half-sheet of modelling composition, softening it, and placing it in the patient's mouth on the side of the bleeding, and the patient asked to close the mouth, not completely, just partially (*fig. 6, A*). It is then removed, chilled, and replaced (*fig. 6, B*). By having this saddle in position, the desired pressure is maintained and a space is provided on the opposite side of

A

B

FIG. 6. Upper.—Compound placed between the teeth; patient closing the teeth lightly.

Lower.—Saddle in position, with space on opposite side for nourishment.

FIG. 7. Barton bandage in position, to maintain pressure

the jaw, through which food may be taken. This dressing should be removed after twenty-four hours, and replaced if necessary.

In addition to packing the socket, hemostatics should be administered internally.

The general directions to be given to the patient, though apparently trivial, are most important, and should never be forgotten. He should be advised to go home very quietly, to avoid all forms of excitement, to assume the sitting position during the day, and to use a high pillow at night. The patient should be fed through a bent tube, and all fluids should be given cold.

In conclusion, we again emphasize the importance of carefully considering the possibility of serious hemorrhage in each individual case.

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RESTORATIONS OF INDIVIDUAL TEETH[1]

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INTRODUCTION

The title assigned for this paper reminds one of the virtue of charity —broad enough to cover a multitude of sins. To speak adequately on all it suggests, within the time available, is as impossible as to write a thumbnail history of the world. This has its fortunate side for the essayist, in that it leaves him free to choose the material he prefers to present, and provides a ready excuse for omissions because of the time limit. Therefore, I shall omit, first, all reference to restorations intended for temporary service, and secondly, restorations in deciduous teeth. Several important sections of the essay will be treated most concisely, with the intent of giving men with special knowledge in those fields, available points for comment, and opportunity to enlarge upon or disagree with statements that will be presented without argument.

Underlying all I shall say, is the principle to which I have schooled all my professional thought for a couple of decades, which does not entirely harmonize with the title. More than twenty years ago, I radically modified the terms in which I thought of restorations of in-

[1] Read at a meeting of the First District Dental Society of the State of New York, at the New York Academy of Medicine, January 2, 1923.

dividual teeth, and began to consider all such restorations from the viewpoint of the relations of the individual tooth to the efficiency and integrity of the masticating organ.

All of you who have been in practice a decade or more, and have given thought to the question of anatomical articulation, proper food mastication, traumatic occlusion, and all the allied problems that confront us in the effort to conserve the function of the masticating organ, can look back to cases in which you restored, or replaced, individual teeth in a manner that satisfied you at the time, which even made you a little proud of your achievements, but which you now know fell far short of the service that could have been rendered, had you then had knowledge of better technic and a broader view of your field.

The major part of this essay will be devoted to the gold inlay-indirect method. The major divisions will have to do with the restorations of individual teeth, in the order named: Gold foil, amalgam, porcelain, silicate cements, individual crowns, inlays.

GOLD FOIL

Gold foil is placed first on the list, partly because of the honorable position it occupied for many decades in dental practice. Its skillful use represented during those decades, and in the estimation of many operators still represents, the highest possible attainment in the repair of the individual tooth suffering from the ravages of caries. I feel there is no question that the manipulation of gold foil was the leading influence in establishing the repute for pre-eminence of the American dentist. It is still considered by the teachers in our schools as the best and most available means of training students in manual dexterity, and in that exact command of the muscles of the hand and arm which is so essential to the highest service in the practice of dentistry. Well placed and well finished foil fillings, in mouths where the patient has taken an interest in maintaining reasonable cleanliness, have proved capable of protecting human teeth from recurrence of caries not only for decades but for half centuries, and even longer. It is, however, a sad and startling commentary on the record of a profession priding itself on its accomplishments in the field of mechanics, that the life of the majority of foil fillings, in the later decades of this pre-eminence, was less than five years.

With the advent of the "two-piece" or "matrix" gold inlay, and especially the cast gold inlay, the foil filling began to fall into disuse. This has been regarded by many of those skilled in the use of foil as a misfortune for our profession and those whom we serve, and for several years our literature contained frequent comparisons, from their pens, of the service rendered by the foil filling and the gold inlay. The articles from those advocating foil as preferable usually carried evidence that their writers were comparing good foil fillings with poor gold inlays, naturally to the great disadvantage of the inlay.

In spite of the high efficiency of a good foil filling in protecting the individual tooth from renewed caries, it has steadily lost ground as the best protection of the individual tooth for most classes of cavities. Both patient and operator prefer procedures making less demand upon the physical endurance of both, consuming less of their time, and offering, in the opinion of a majority of the profession, better protection for the patient, namely, the cast-gold inlay. The objectionable features of foil filling operations can be safely reduced to the minimum, by an intelligent command of the principles of modern cavity preparation; by the use of a properly contoured and supported matrix in proximo-occlusal cavities; by the use of soft foil for the gingival third, or half, of such cavities; and by the use of the electric gold annealer and pluggers with enlarged ends. This last feature will save one-third of the time required for placing cohesive gold, by reducing the number of motions required.

Leaving aside the two elements, greater physical endurance and time demand upon the patient and operator, I want to stress another point, which seems to me to have great weight in the discussion, I desire to call to your attention that it was formerly as it is today, almost universal practice for operators making gold foil fillings in molars and bicuspids, to finish the occlusal surface of those fillings with revolving engine instruments of such size, shape and quality as must result in a curved, but smooth, occlusal surface, with little or no indication of sulci and marginal ridges. I am aware of the fact that here and there an operator has presented a claim that he can and does establish marginal ridges and sulci in such foil fillings. It has been my habit in recent years, when in contact with graduate students, and this point has come up for discussion, to say to them that, if they can

make good foil fillings which restore the occlusal form and occlusal efficiency of masticating teeth, then by all means to continue that practice. But unless they can do this, they have no right to continue to make such foil fillings, in view of the higher efficiency and usefulness of the equally protective gold inlay, by which such surfaces are easily restored to approximate normal outline. Therefore, granting the claims of the competent advocate of the foil filling for proximo-occlusal cavities in molars and bicuspids, namely, that, if perfectly made, there can be no better protection against recurrent caries, and that it is possible so to do the work as to bring it within the range of reasonable physical endurance, nevertheless I hold that such fillings are inadvisable except in the hands of operators who can and do restore the occlusal surfaces to approximately normal shape.

In my estimation, the foil filling should still be selected for limited classes of cavities. These are in general the smaller cavities in Class I, and the Class II cavities where the outline of approximal cutting and the tooth form are such as to mean much more extensive cutting in order to use an inlay. It is my belief that many proximal cavities in upper incisors and cuspids, which are being filled today with silicate cement and sometimes with porcelain inlays, might much better have good gold-foil fillings. I have some sympathy with the claim for the usefulness of the foil filling in small proximo-occlusal cavities in lower bicuspids, where the form and size of both tooth and cavity is such as, to make an inlay, would involve considerably more cutting of otherwise sound tissue, especially the cutting of an occlusal step that would encroach upon or extend across the transverse ridge of the tooth.

I am in favor of filling all cervical cavities in buccal surfaces (even in labial surfaces when the lip habit of the patient or a heavy mustache reduces visibility to a minimum), with gold inlays rather than with foil fillings, silicate cement, or porcelain inlays. My reason for objecting to foil fillings in these locations is, that the proper finishing of fillings extending to or beyond the gingival margin, as is the case with a large percentage of them, frequently means so much injury to the gingivae and gingival portion of the peridental membrane that these tissues never recover their normal condition. The gold inlay for such a cavity can be entirely finished before it is set, so that there is no

excuse for mechanical injury to these vascular tissues, and the surface of the inlay can be left definitely and permanently smooth.

In the case of the proximo-occlusal filling in cavities of exceptional shape, I would prefer to overcome the objection by modification of preparation, or by the use of supplemental inlays rather than to forego the restoration of marginal ridges and sulci.

AMALGAM

In spite of many years of devotion to the making of the best foil fillings I was capable of, and then to the making of the same type of gold inlays, I would reiterate what I have repeatedly stated on society platforms, namely, that if the profession were to be compelled to surrender all but one of its filling materials, the one to be saved should be amalgam. The fact that it is an inexpensive material as compared with its only other competitor—gold—and that it requires less equipment and makes less demand upon technical assistants, enables the profession to place it within reach of a larger number of patients than any other one permanent filling material.

You will note that I have omitted to claim for it any marked saving of the operator's and patient's time. I have done this designedly because I have considerable doubt whether the making of the best and only right kind of amalgam fillings in the cavities for which it is best adapted, can be done so as to show much saving of time when compared with effective and well coördinated gold-inlay work.

The making of a good proximo-occlusal amalgam filling means the expenditure of a great deal more time and effort than is generally devoted to it. First, it is imperative that the involved teeth shall be separated by some form of wedging, a process disagreeable to the patient and frequently an annoying interruption in the daily routine of the operator. Secondly, cavities for amalgam need the most exacting care in their preparation. I am opposed to leaving softened or infected dentine under a permanent filling in any cavity, but I have always felt that it was imperative that a cavity for an amalgam filling should be more thoroughly cleaned and sterilized than for any other filling we deal with, because of the possibilities of leakage as the result of changes in volume during the crystallization process. Of course, this factor is less important now than it was twenty to thirty-five

years ago, when I was making many more amalgam fillings than in recent years, because of the advance in the quality of present-day dental amalgams. I regard it as imperative that matrices shall be used, which shall insure correct proximal contour (this excludes all band matrices), that the material shall be packed with extreme care, using force enough to insure contact with the walls, that the occlusal surfaces shall be carved to a normal restoration of form, that all surplus shall be removed before the amalgam sets hard, and that the resulting filling shall be highly polished at a subsequent sitting.

Just as long as these precautions are observed, amalgam will do good service for our clientele, and just in proportion as they are neglected, will it fail to do good service. Unfortunately, the observance of these rules means an expenditure of time that may frequently equal, or in my estimation often exceed, the chair time required for cavity preparation and insertion of a gold inlay that will be of greater service. In this connection, I want to call to your attention the Dyack sulci instruments for the carving of occlusal surfaces. They impress me as having an especial adaptability for amalgam work.

PORCELAIN INLAYS

It is interesting to many of us who passed through the first great wave of enthusiasm for the porcelain inlay, which occurred some thirty years ago, and then saw it fall into disuse partly because of its own inherent defects and difficulties, and partly because of the tide of popularity of the silicate cements, to see the recurrence of interest in the porcelain inlay. Only a limited percentage of practitioners are willing to give the required study and time to develop high efficiency in the technic of the porcelain inlay, and the knowledge necessary to the proper control of the colors and shades. For these few, porcelain is a valuable aid in a limited percentage of cavities; and, where competent technicians are available, other practitioners who are willing to fit themselves to carry out the required technic can also avail themselves of the inlay.

In my estimation, the correct use of the porcelain inlay is limited to those cavities in which it provides an esthetic value for the restoration; or, in other words, cavities where any filling not of tooth color, will be unduly disfiguring. This means labial cavities, and occasional

approximal cavities and corners of the eight front teeth. I do not favor the use of porcelain inlays in buccal cavities, in spite of the fact that the surface of the porcelain itself, when properly fused, is acceptable to the vascular tissues. My reason is that, in nearly all mouths within one or two years, the cement line dissolves sufficiently to leave a sharp margin of cavity and inlay, and a minute ditch for the collection of debris under the gingiva; and that these margins and debris result in more irritation than that of a suitably finished gold inlay in the same location. I oppose the use of porcelain in proximo-occlusal cavities in molars and bicuspids, except occasionally in the mesio-occlusal of the upper first bicuspids, because of lack of strength and difficulty of restoration of occlusal form.

Very earnest and frequently very successful efforts have been made for the restoration of missing corners of incisor teeth with porcelain. The high technical skill demanded, the difficulty of its maintenance in view of the comparatively infrequent demand, the shadow problems in otherwise successful cases and the fragile character of the material, explain the tendency to adopt the porcelain jacket crown in such cases, even when the amount of missing tissue is comparatively small. An alternative offering great permanence and pleasing appearance is the cast-gold inlay, with a recess in the labial portion to be filled with silicate or porcelain. Of late years silicate has been my choice for use with such inlays, so located that its replacement shall be simple, and without probable need for further tooth cutting.

SILICATE CEMENTS

This much overrated material has a limited legitimate use. Its brittleness and its lack of adhesion disqualify it for permanent service in any place except where its esthetic value overbalances these defects. It is helpful for use in labial cavities, some proximal cavities in front teeth, and as an inset for a covering of gold that would otherwise be objectionably exposed to view. For the first usage the readiness with which it becomes etched in many mouths is unfortunate. For proximal cavities it is serviceable and frequently desirable where other fillings would result in disfigurement, but foil fillings are much better and more reliable; and for such cavities as can be opened from the palatal surface, and filled with foil with a minimum exposure of the

gold, it is a much better service to the patient to make foil fillings. Even when used with the utmost care, there is a large percentage of mouths in which the silicate fails to seal the cavity adequately, and the promptly occurring defective margins due to the brittleness of the material, and the frequent tendency to early discoloration, mean enough replacement of fillings to result in undesirable enlargement of the cavities involved. It is distinctly not a safe or satisfactory material to use for large restorations in molars and bicuspids, because of the defects already mentioned. I have had no experience with it in such situations, and am not prepared to express an opinion as to the dangers of pulp involvement as the result of such use. I speak of pulp involvement because of recent reports of that sort, although some of the cited cases were evidently due to disease already incipient, or well established before the placing of the cement.

For many years there were frequent discussions of pulp injury by oxyphosphate cements, but it is my belief that almost without exception such injury occurred in cavities not properly cleaned of carious dentine. It is an open question in my mind whether the same will be found true with regard to the silicates. It is my experience that in mouths where oxyphosphate cements dissolve rapidly, the silicate-cement filling in small cavities presents a pleasing appearance as long as does a porcelain inlay, because of the ditch that opens quickly at the cement line when the latter is used, and becomes packed with debris, causing a disfiguring dark line and shadow effects in the inlay.

INDIVIDUAL CROWNS

For individual crowns, the writer's choice for many years has been the crown with an all-porcelain top, almost without exception made especially for the case, mounted on a well-fitting and adequate gold base. It is most unfortunate that the practice of making such special porcelains has fallen into disuse, in view of the great difficulty of getting porcelains of correct color and form even for ordinary cases, to say nothing of those in which there are erosions and other defects to be matched. It is to be hoped that the tardy realization on the part of the manufacturers that the yellows of natural teeth can be successfully imitated only by the use of deep orange as the basal shade, will eliminate the unnatural muddy browns which have so long held sway.

I realize that the problem has not been an easy one, but the fact that one manufacturing company solved it several years ago, and that a second one has recently announced the adoption of orange as its basal shade, is encouraging.

More recently this type of crown has been reserved, in my hands, for the cases in which bridge or denture work was to be coördinated with it, and a porcelain jacket has become the standard crown, not only for the comparatively rare instances in which it was needed on vital teeth, but also for pulpless teeth. The best protection for such teeth is provided by a gold cope and band cast in one piece. The portion replacing the band of the typical banded crown can be finished to the inlay type of margin and have the necessary contour to restore normal tension of the gingiva, the central core being built up in gold in imitation of the typical preparation for the vital tooth. With a technician familiar with both enamel jacket crowns and those made from body and enamel, the artistic possibilities and strength of such crowns leave little to be desired.

CAST-GOLD INLAYS

At the present time, the cast-gold inlay provides the highest class of service for masticating teeth most needing restoration. Its one element of inharmony—its color—is constant, although capable of material modification by use of platinized alloys, which are decidedly less noticeable in the mouth than the more pronounced yellows of pure gold or the copper alloys. The ease and certainty with which the external form of the missing parts of teeth, and hence their function, can be restored with cast-gold inlays; the fact that such inlays serve adequately to protect the filling material most acceptable to vital dentine from attack by the mouth fluids; and the condition that extensive restorations on fragile teeth can be so applied as to conserve all the remaining strength of such teeth, with a minimum of injury to the associated vascular tissues, should lead us to remember with constant gratitude the service of William H. Taggart.

A great deal of argument in our ranks during the last fifteen years would have been unnecessary, if we could have arrived at a common understanding as to the characteristics of the ideal inlay. There is no question that Dr. Taggart, when he announced the cast-gold inlay, was,

and I believe still remains, the final authority on the technic of gold-casting. I believe very few, if any, steps in technic have been announced since Taggart first gave us the successful cast-gold inlay, that had not already been foreseen, practised, or reasoned out theoretically by Dr. Taggart, and I want to make clear at the start my great admiration for his achievements in that field. I feel that the treatment accorded him, by the dental profession, is one of the most shameful pages of its history.

The question as to what are the characteristics of the ideal inlay is one quite apart from the technic of making such an inlay. With all regard and friendliness for Dr. Taggart, I hold that when we step into that field, we find that instead of one final authority, there are several thousand men whose standing as operative dentists and keen observers is such that their opinions are entitled to careful consideration, and it is the concensus of opinion among these men that will finally define the characteristics of the ideal gold inlay. It is my understanding that Dr. Taggart and many of his disciples hold that the ideal inlay must imitate as closely as possible, as regards the fit to the interior walls and margins of the cavity, the characteristics of the ideal gold-foil filling, i.e., that the gold must fit within the cavity as the hand fits within a close-fitting glove, and that the finished margin of the inlay must be exactly flush with the margins of the cavity. It is the judgment of many able members of the profession that this close fit between the inlay and the interior of the cavity is not only unnecessary but frequently detrimental, and that in vital tooth, with a cavity of medium or large size, it is always hazardous.

I hesitate to attempt to speak for the advocates of the close-fitting inlay, because of the fact that I have no confidence in the merit of the claims they put forward concerning the need for that close adaptation of the two surfaces, and also because I regard its attainment as a definite menace to the welfare of the tooth in which such inlays are inserted. It is my understanding that the reasons advanced to support the claim as to the essential need of this close fit are: better retention of the inlay by frictional contact with the cavity walls, lessening of the risk of flow of the gold under stress, and avoidance of the risk of crushing of the cement setting as the result of impact. I have little doubt that all three of these factors exist as long as 24 K.

gold is used, or any other gold which, when cast, approaches it in softness. On the other hand, I desire to state dogmatically that none of these three problems exists when a gold of the proper degree of hardness and toughness is used for the cast inlay, and when it is inserted in a properly prepared cavity, with close contact between gold and tooth at the inlay margins.

One of the reasons for my prompt adoption of the two-piece matrix gold inlay, which preceded the cast inlay, for all large and medium sized restorations, was the opportunity given for the insertion of an insulating layer of cement under the inlay. There are other controlling reasons why I prefer the indirect system for making gold inlays, but one of the most important is the ease with which a substantial layer of cement can be interposed between the gold and all vital walls when that system is used. During all my professional life, it has been my habit to interpose such a layer of material of low thermal conductivity between metallic fillings and pulpal or axial cavity-walls whenever there was room for it. With the two-piece inlay and the cast inlay, I promptly realized the opportunity, and practiced the interposition not only of that limited cement layer, but also its extension nearly to the cavity margin.

When the statement was made a few years ago at a meeting of one of our sister societies, that there is little difference between the thermal conductivities of our zinc cements and gold, I asked for an opinion on this point from the Bureau of Standards at Washington, which I believe to be one of the final authorities, if not the final authority in such questions. After explaining that a complete answer was not feasible because of the absence of available data on the zinc salts, the Bureau stated that the "conductivity of cements made from zinc salts will certainly be less than 1/100 of that of gold, unless the former are very extraordinary substances, unlike other metallic salts." In view of our professional attitude regarding the conservation of tooth pulps not only in vital, but as nearly as possible in normal condition, this fact becomes of great importance in our work, and I conceive it to be essential that we shall so arrange our technic as to take advantage of this protective quality of the cement used for setting our inlays. It is this fact that has led me to state on society platforms and to students that I regard my inlay not as a gold filling, but as a protective

cover for the real filling, which is the cement underlying it. It is common knowledge to every practitioner that vital dentine accepts more readily the presence of a good oxyphosphate cement than any other filling material available to us. With these facts as a basis, I am in the habit of defining an ideal gold inlay as "an inlay that accurately restores the contour and occlusal shape normal to the involved tooth in the existing condition of wear in the mouth under treatment, resting in a cavity so prepared that the uncemented inlay can be dislodged by stress in one direction only (that being the direction opposite to the one from which it is inserted), with margins overlapping the cavity margins slightly on all proximal surfaces, and fitting closely against the sound enamel surface adjacent to the cavity margins on the proximal surfaces, and to the cavity margin itself on occlusal surfaces, and with a material thickness of cement interposed between it and all interior cavity walls."

It is obvious that, if the operator confines himself to the use of very soft golds, such an inlay will lack durability because the flow of the soft gold under stress will promptly unseat it. It is the constant testimony of a large and growing number of our ablest practitioners that no such risk exists when a gold of suitable hardness and toughness is used. It is coming to be accepted that a logical degree of hardness for gold restorations that include occlusal surfaces is one that will provide wearing qualities approximating those of the other teeth in a given case. If this specification be met, there need be no fear of disintegration of the underlying cement from the impact of the opposing teeth, and the thicker the cement over the floor of the cavity, the less likely for this to happen. A cement filling from a correct mix rarely, if ever, fails by disintegration because of such impact; and when it is under a fairly hard and thick layer of gold, it is almost inconceivable.

The advent of the cast-gold inlay found a considerable number of dentists already well established in the use of two-piece matrix inlays for all medium and large gold restorations. This being necessarily an indirect process, these men were naturally predisposed to consider the adaptability of that process for the cast inlay. In this vicinity most of these men were personal friends of Dr. Taggart, with deep sympathy for him in what they regarded as unjust attacks then being

made upon him, and they hesitated to make statements concerning inlay procedures not endorsed by him, because such statements were immediately construed as attacks upon Dr. Taggart. Partly because of the attacks upon him, and the sympathy of men who followed closely all the procedures recommended by Taggart, these latter were outspoken and even bitter in their comment concerning such variations of technic. These facts and the conservative spirit, which demand the testing of all procedures thoroughly, have led to a too conservative attitude of the advocates of the indirect process for making cast-gold inlays. Obviously erroneous statements concerning that process have been allowed to pass because of reluctance to enter into discussions with men whose rejoinders involved offensive personalities. In the opinion of the speaker, however, the time has arrived when definite physical facts should receive adequate consideration.

One of the unfounded claims of the opponents of the indirect system has been that it gave opportunity for so many more chances of error as compared with the direct. The men making this claim usually coupled it with that transparent absurdity that the casting process duplicates absolutely the wax pattern, and bolstered their position with much talk of science, failing to realize that the word "absolute" is one of the rarest in the vocabulary of the true scientist. Strangely enough, our literature is replete with essays from the pens of direct-process advocates explaining how to overcome the errors, and the tendencies to error, of almost every step in their process. It is obvious to all of us that, when working with materials susceptible to change of volume with every change of temperature, to change of volume during crystallization and other chemical reactions, and to change of volume with changes of moisture percentage, absolute accuracy, or even approximate accuracy through all of these changes, is possible only under the most exacting scientific laboratory conditions. Will any one of you claim, or even admit, that such conditions are possible in one per cent of our dental laboratories? I am quite ready to admit that careful technic and constant watchfulness produce castings, by the direct process, that are sufficiently accurate to serve our purpose. I desire, however, to point out to you the reasons why I believe better castings can be provided by the indirect process, and I hold that the errors common to both processes can be more safely corrected when the indirect process is used.

The tendency to error in obtaining an accurate impression of properly prepared cavity, and in making a wax pattern that shall record the form of the cavity and margin, are equal. In both instances we deal with a material made plastic or semi-plastic, by heat, which condition may be retained under pressure while it cools to mouth temperature, or is cooled to less than mouth temperature, and so probably counteracting in some degree the tendency to shrinkage while cooling. The second step of the indirect process—the making of the amalgam model, or replica of the cavity—has no exact counterpart in the direct process. I believe few men of experience, however, will question that ordinary laboratory procedures, such as may be taught in a few days to almost any person with fair mechanical aptitude and capable of following instructions, will result in a substantially accurate replica of the cavity and of the adjacent parts of the tooth. From that point on, the chances of error in the two processes are the same. In both there will be many errors, some of them controllable with care, some of them in a degree compensating each other, and the final result always calls for instrumentation for their correction. If the inlay gold is soft enough to permit of that instrumentation in the mouth without grave risk of injury to the cavity margins, then it will be too soft for efficient service. Especially is this true if the inlay margins on proximal surfaces are finished flush with the cavity margin. With the indirect process and the overlapping margin, the accurately made amalgam model provides for nearly all of this instrumentation with the inlay seated in that model, so that when the inlay is transferred to the cavity , little or no instrumentation is needed at the margins.

It is held by some that the use of overlapping inlay margins results in a constant tendency to leave them projecting under and into the gingivae. This is true if the work be done carelessly, and it is to be met and overcome just as any other tendency to defects is overcome. Its control is merely an incident to the careful operator, just as is control of the constant tendency to make castings by the direct process that are not quite flush with the cavity margins on proximal surfaces. If you doubt this tendency, test the next fifty or one hundred inlays that you know have been done by the direct process, and see how many, when examined with a fine explorer, have unprotected enamel margins on proximal surfaces which stand out be-

yond the surface of the inlay. I admit that the overlapping margin on proximal surfaces can be reasonably well provided by the direct process, especially since the direct-process advocates are beginning to adopt the long practiced procedure of the indirect workers—the trimming back of the tooth contour on those surfaces so as to provide an overlapping flap with a thin edge. I believe it is decidedly easier to establish this overlap with accuracy on the amalgam model.

To Dr. M. L. Rhein credit is probably due for the earliest and most outspoken advocacy of this preparation, although others independently discovered its value. It has been recognized for years by indirect inlay workers, not only as an essential element of correct cavity preparation for the indirect process, but also as a valuable and important factor in attaining the best possible results in tooth protection. Even one year ago, however, I should have felt it necessary to go at some length into explanations justifying its use, because I should have expected vociferous opposition. However, Prof. Chas. K. Buell, of the Buffalo School recently published (*Dental Items of Interest*, December, 1922) an article advocating this same preparation for the direct inlay process and credited Dr. H. E. S. Chayes with introducing him to it, and I assume it is unnecessary to do much more than call to your attention the actual facts and to show you on the screen pictures of such preparations.

It is obvious that with the preparation of the typical m.o.d. cavity until recently endorsed by direct-process advocates, in which proximal contours were left untouched, an accurate cavity impression could not be taken. With the inclusion of that one feature of contour elimination, in the direct-process cavity preparation, the preparation for both processes becomes identical. An accurate impression of the cavity and of all the tooth, except that part between the point of highest contour and the cervix on the buccal and palatal, or lingual surfaces, becomes readily possible. The resulting model provides all the necessary indicators for the technician to complete a properly contoured restoration.

Time limits forbid any lengthy description of cavity impression, or bite-taking technic. Briefly, the impression technic I have found most satisfactory, after trial of all those I have heard of, calls for a seamless 36 g. soft metal band and Kerr Modelling Compound. The

bite is most accurately taken when two plates retaining the wax on the buccal and palatal or lingual sides of the teeth are connected by gauze, or architect's tracing paper, with wax placed between them—in other words, the mush bite with a retaining device for the wax preventing its flow bucally and lingually.

To sum up briefly, before showing you a few slides, it is my understanding that the advocates of the direct-process inlay endeavor to *cast* an inlay that fits, and it is my belief that in so doing they subject both themselves and their patients to unnecessary difficulties and hardships. They accept the hazards of restoring contour, occlusal form, and production of satisfactory margins under much more difficult conditions, and their technic becomes progressively less satisfactory as the cavities involved increase in size, in complexity and in difficulty of access. It is my claim that the casting of an accurate fit is uncertain and doubtful under ordinary laboratory conditions; more important still, that such an inlay is unnecessary, is a menace, and is frequently detrimental to the teeth and to the patient's welfare. On the other hand, I hold that no restoration is too complex or too far back in the mouth to lend itself readily to the indirect process; that satisfactory form reproduction is more feasible; that with the aid of the amalgam model of the tooth, discrepancies common to all inlay-process steps and frequently undiscoverable without it, are readily observed and corrected; and that the invaluable element of a generous layer of cement interposed between cavity walls and inlay, sealed in with an inlay margin spun down to contact with sound enamel rods, is more easily and hence more surely attainable. It is a possible objection to the indirect process that the aid of a skillful technician is essential to good results, but this objection has been surmounted so often by the training of such an assistant that it can scarcely be considered a vital objection.

The technic by which the more successful advocates of the direct process arrive at the beautifully smooth castings, with very close adaptation to cavity walls, challenges the admiration of every operator who appreciates mechanical nicety and exactness of execution. In my estimation, however, it will be a happy day for our clientele when worship of mechanical skill is tempered with a broader conception of the therapeutic needs of the sick tooth, and of the welfare and comfort of the patient.

The great advantage of being able to bring the casting to the amalgam replica of the tooth, to observe readily variations in its form, due to errors in any step subsequent to the making of the amalgam model, and to correct those errors on a refractory model, so avoiding risk of damage to cavity margins, is an important thing in all cases, and especially is it important in the more complex and extensive work where very hard gold alloys are frequently desirable. The incidental advantages of having a model on which to do the finishing and polishing instead of doing it in the mouth, of being able to make as many wax patterns as may be desired in case of any failure in the process subsequent to the making of the wax form, may be passed with mere mention.

Having provided the slight overlap at the margin, with its thin edge rapidly thickening as it joins the body of the inlay or by the preparation described, and by the subsequent steps, a thin-margined flap or wing on proximal surfaces, and a similarly shaped margin of occlusal portions of the inlay by cavity margin, bevel and sulcus carving, consideration of the management of these margins is important. It has been repeatedly stated that such a margin cannot be adapted to the tooth by instrumentation—those so claiming basing their statement on the old truism that a flat gold plate when "burnished" curls towards the instrument. The futility of that illustration should be apparent to any one who compares the physical conditions of the two cases. The thin knife-shaped inlay margin attached to the solid body of the inlay, at its thicker portion, bears no resemblance to the flat plate, and the correct instrumentation resembles burnishing only in that the instrument called a burnisher by generations of dentists is frequently used. It should, however, be used in such a manner as to spin the margin into contact first with the amalgam model and, as a final step, with the surface of the tooth. Crimping, or bending, may appeal to some as a better term, but in any case the instrument used should be so applied at such an angle to the margin and tooth as to avoid stretching the gold, but to force the gold margin into close contact with the tooth surface, and to pinch off the thin film of cement while it is still in a plastic condition.

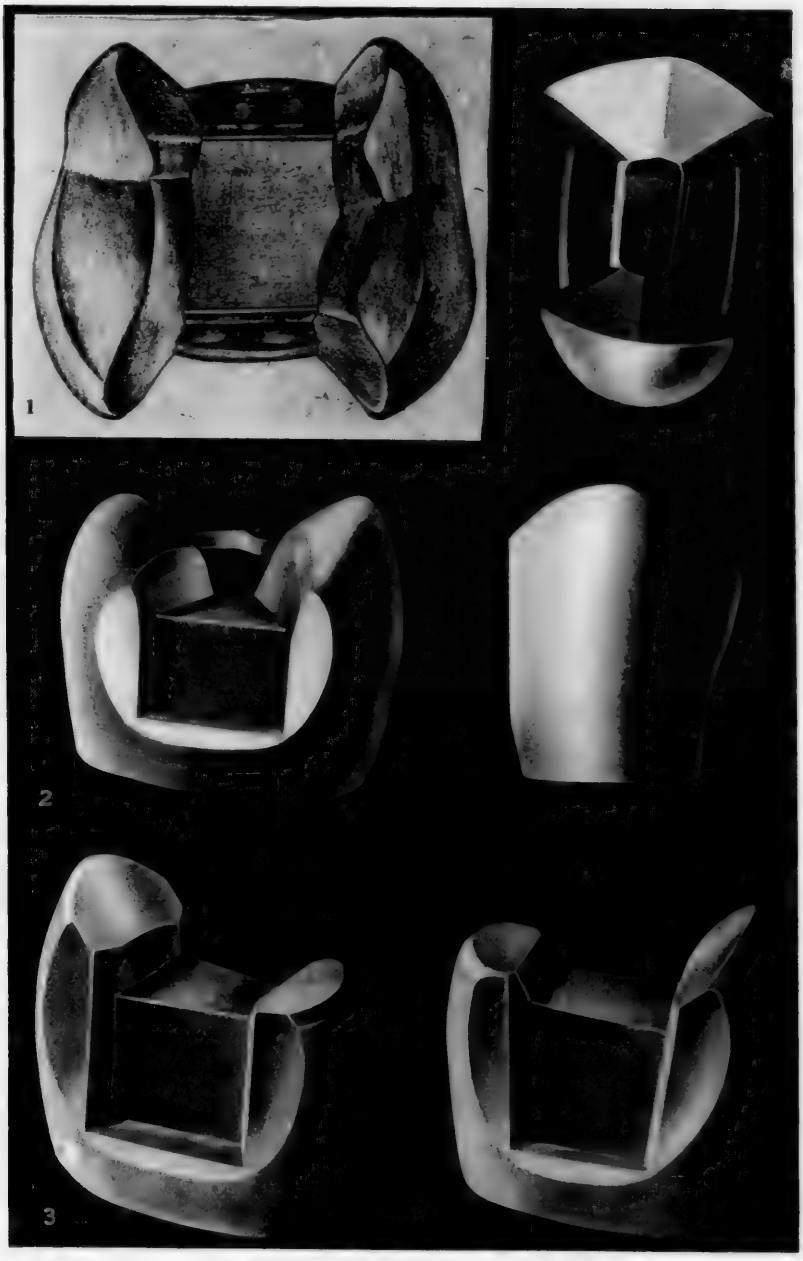
140 West 57th Street.

PLATE 1

FIG. 1. Preparation for an m.o.d. molar cavity (Dr. Marcus L. Ward), and for an m.o.d. bicuspid (Dr. F. C. Cole); both for the direct system. It is obvious that good impressions for an indirect inlay can not be made by these preparations, by any practicable method, because of the distortion that must result from the withdrawal of any impression that will show with accuracy both the cavity and the parts adjacent to its margin, which are essential for a model and for the proper guidance of a technician.

FIG. 2. Direct and profile view of correct bicuspid preparation for indirect-system inlay, and now accepted as correct by many direct-system operators. The cut by which the contour has been removed may preferably be less nearly parallel to the long axis of the tooth, if conditions permit, as is indicated by the line on the buccal surface. By so placing it, the demarcation of its margin, on the cut apically to the cervical margin, is more pronounced on the amalgam model. It is important to have that line appear plainly in the amalgam, so the technician may have a clear indication where to lay the margin of the finished work.

FIG. 3. Preparation for an m.o.d. indirect-system inlay in a pulpless bicuspid much weakened by caries.



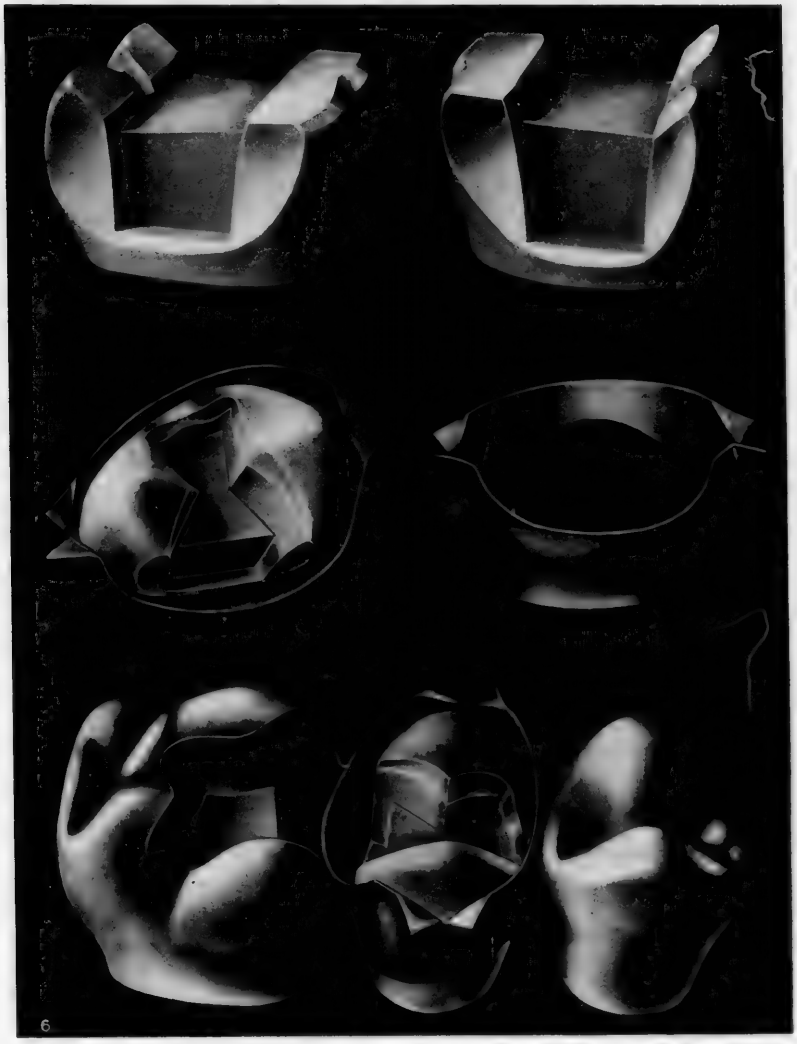
(Gillett: Restorations of Individual Teeth)

PLATE 2

FIG. 4. Preparation for m.o.d. indirect-system inlay in a pulpless molar much weakened by caries.

FIG. 5. Seamless band prepared for taking cavity impression, and same band in correct relation to a bicuspid tooth, with proximo-occlusal preparation. Note that the occlusal aspect of the band does not project beyond the occlusal end of the tooth. This is important in eliminating risk of gum injury by crowding the band into the gum when forcing home the block of impression compound. It is especially important in an m.o.d. preparation.

FIG. 6. Another view of the same band, and its relations. Note that it does not pass between the bicuspids, but rests against their contact points.



(Gillett: Restorations of Individual Teeth)

DISCUSSION

Harry Jerome Baker, D.D.S. (*Boston, Mass.*): I desire to take this opportunity of expressing my great appreciation of the invitation to appear before the First District Society of New York. I feel assured that to whomsoever this privilege is extended, it is regarded by the recipient as a great compliment. It also affords me a great deal of pleasure to be present and pay homage to Dr. Gillett who is an honorary member of the American Academy of Dental Science of Boston, and we are proud of that fact. His retirement from active practice is a loss to his clientele but we hope that he will continue active in dental circles for many years. I have greatly enjoyed his paper for it is instructive and wonderfully concise for the wide range it covers.

Your society enrols many of the most prominent and most careful thinkers of our profession, and many of you practice among an exclusive clientele. For these reasons, I esteem it an unusual opportunity to dispute some of the declared objectionable qualities in amalgam work, for I know that men of your type are always receptive to facts. Time will not permit me to discuss details of technique but rather to declare some of its results and to discuss briefly the outline as set forth by the essayist.

The material which I propose to offer for your consideration is the result of my observations during the past seven or eight years. It is founded on a personal review of all I have been able to find that has been written on the subject of amalgam, past and present; on personal investigations; on results in private practice, and on a large experience with work done by others, some of the latter having been done under supervision. These give me a degree of assurance to speak in a positive manner which I trust you will not regard as dogmatic.

In New England, I have been called "The Amalgam Missionary." Very likely because I have responded so generally to the many calls I have received to attend dental meetings. I have been so enthusiatic over the results from an improved technique, that it has given me the ambition to spread the gospel which has seemed to accomplish such satisfactory results.

I am confident that when the "rank and file" of the profession awaken from their Rip Van Winkle slumber to the necessity of a wiser choice in the selection of their alloys, and to the necessity of acquiring and practicing an improved technique, they will be astonished, as I have been, to find that many of the vagaries which were formerly inherent in amalgam have very largely disappeared with the improved alloys, properly manipulated, and they too will marvel at the beautiful, permanent results which are possible.

In fillings made from amalgam, which have been under observation for seven or eight years, both in private practice and even in work done by students under supervision, flow, spheroiding, leakage of margins, and blackening are not in evidence in the majority of cases. In fact, the margins compare very favorably with those of many gold inlays which have come under my observation in the work of different dentists. The more I observe our two standard filling materials, amalgam and gold, the more convinced I am that they are mighty reliable, and that technique plays a very important part in their perfection and durability.

Oxidation of amalgam fillings is not prominent (you will please remember the type of amalgam work I am referring to) among such patients as follow instructions in regard to making a conscientious attempt to cleanse them vigorously during their daily use of the tooth brush and dentrifice. I mean, however, a little more elbow grease than is commonly used on posterior teeth in brushing. The highly polished, dense surfaces of such fillings and restorations inserted under the technique I have in mind, oxidize only *very superficially* and can be kept bright and clean in the average mouth. I have no doubt that some of you consider these statements as extravagant but I could produce much evidence in proof of my remarks. (Specimen exhibited.)

I am in perfect harmony with the essayist in the majority of his statements but am more radical than he in favor of amalgam. It is, indeed, the one material of which the profession cannot be deprived but the fact that it is inexpensive; as compared with gold, does not furnish a rational basis for the establishment of a fee. The responsibility for inadequate fees rests squarely on the shoulders of the profession. The trouble is that amalgam has been cheaply used as a cheap substitute for a more expensive material or in lieu of a technique which was thought to consume more time. If time permitted discussion of the details of what I consider a correct technique, none of you would deny that it consumed time enough and was sufficiently exacting to warrant a substantial fee.

How many of you have read what Black says in this connection? Let me quote from page 329 of his Operative Dentistry: "Fillings made from the modern amalgams are a close second to gold in their durability and protection to the teeth against the recurrence of caries. The difference is that *amalgam* is the *more difficult to make perfectly. It is more difficult to learn the manipulation* and *even then is more difficult to secure perfect results regularly*, filling after filling." This was written at a time when manipulation was even less exacting than now. I interpret Black as speaking of technique and not of the vagaries of amalgam, and I think the text which follows this quotation bears me out.

I used the term Rip Van Winkle slumber at the beginning, but intended no offense and submit that the majority of dentists have been asleep to the importance of the above quotation.

I have said that amalgam was cheaply used. Indeed, I know of no other filling material which can be subjected to such gross abuse and still yield as creditable results from the viewpoint of saving teeth. To men of your intelligence I need not enumerate those abuses.

The essayist of necessity briefly hinted at the importance of cavity preparation but I appreciated his insistence on the subject. Cavities for amalgam *demand* and *must receive* the same careful preparation as those for gold foil or the gold inlay. Inattention to this detail of itself has been the cause of failures in amalgam work. I believe that in the preparation of the cavity for amalgam, there are some modifications from the Black system for gold. These, I think, are important in effect if not in degree. They appear to be somewhat numerous in the range embraced, the simple pit cavity and the full amalgam restoration, or amalgam crown so called. I have evolved what I hope may be the beginning of a system which consists largely of modifications of the Black system. This is giving excellent satisfaction in private practice and particularly also from the viewpoint of teaching. I hope to publish it soon, with the purpose of evoking criticism and additions, for it is by no means complete.

Dr. Gillett has emphasized the unpleasant effects of previous separation and I think said it was quite necessary. May I say, I do not resort to it, but accomplish the result of a normal contact point by other means. I resort to previous separation only in cases where the teeth have drifted, usually on account of long standing and extensive caries or where the interproximal space has been lost in some degree. This technique originated in the Tufts Dental School, I believe. It is accomplished by a sufficient packing force, directed at the proper angle against the matrix, when the cavity is sufficiently filled to approximate the position where the contact point should be established. By this means the matrix is stretched slightly and the teeth are forced apart a distance that is fully equal to the thickness of the matrix material. When it is removed, the teeth should be as close in their relation to each other at the contact point as in normal cases. This has been demonstrated with regularity in practice and by students under supervision. I think that Dr. Martin Tracy has seen some of the amalgam work done at Tufts and will agree to most of my statements. The use of a thin, smooth, unpunctured matrix assures a contact point as smooth as the metal itself and one which requires no shaping and finishing. (Specimen exhibited.)

I do not quite understand Dr. Gillett in his discrimination against band matrices unless he refers to one made by Ivory, the matrix of which is only long enough to encircle the tooth partly and has holes punched at each end to engage a retainer which has a spring or acts as a spring. I think it is designated as No. 1 but am not sure. If he refers to this type I heartily concur and personally condemn it, for one is sure to toboggan the amalgam under the cervical margin if he packs with force. On the other hand, some types of band matrices are useful. I find the No. 8 Ivory Improved very useful in many instances and constantly employ it for such cases as are not so extensive that they require a support during the process of hardening, on account of the occlusion. It greatly expedites the carving process to be able to remove the matrix early in that procedure. The bands which are furnished entirely encircle the tooth and are so shaped as to hug the cervical wall. The newest addition, No. 9, I am not so enthusiastic about. Matrices are legion and many are useful in some cases but I employ chiefly the No. 8 mechanical retainer, the sheet metal matrix, and the seamless copper band, and I never use a punctured type. In any event, overhang at the cervical margin must be prevented and is inexcusable. It can be avoided and is due to an unwise choice of the matrix or a faulty technique in its use.

The essayist was careful to emphasize anatomical restoration, which is important in many ways. The anatomical restoration of contact points, cusps, their inclined planes and sulci, must be assured in order to restore the functions of the teeth, not only in the masticatory process, but also to preserve proper balance in occlusion, the proper antero-posterior relation of the mandible and the interproximal spaces. We must remember that the predisposing cause of many cases of orthodontia is the faulty restoration of the cusps and their inclined planes, particularly in the first molars of young children. Dr. Young of this city was among the first to recognize this and his article in *Dental Cosmos* several years ago, on anatomical restoration in connection with amalgam work, has been a valuable incentive to many, and the original one to me, to develop a better technique. Incorrect occlusion also causes a loss of balance and traumatic occlusion, which defects, as well as the loss of interproximal space, predispose to periodontoclasia.

My technique differs somewhat from that of the essayist in regard to finishing margins. On those which are easily accessible, I am not disturbed if I leave some overplus at the time of carving. In fact, I frequently leave some just as we are advised to do with synthetic. At a subsequent sitting, when the patient returns for the finishing and polishing of the

filling, this overplus is disked down with fine grits. Margins not easily accessible to this mode of finishing are finished at the time of carving.

Leakage at the margins is very often enumerated as one of the great objections to amalgam and the cause is usually attributed to volume changes in the filling. It is true that volume changes have been the cause of leakage, which is also caused at the present time by the use of inferior alloys, but I am inclined to believe that, in the type of alloys of which I am speaking tonight, volume changes are not so much the cause of leakage as is *faulty manipulation* and a lack of plasticity during packing—a rather radical statement but one that I believe is correct as I intend you to interpret it. In speaking of the fillings which have been under observation, I can state that movement is not common to those inserted under improved technique and that volume changes are well under the ability of the operator to control to a very large degree, notwithstanding what Black has said to the contrary. This is a very interesting point upon which to enlarge but time does not permit. I wish to fortify myself in regard to the foregoing by stating that I am speaking from the viewpoint of the most careful selection of the alloy and the most painstaking endeavor to follow a prescribed technique, which is within the ability of any dentist.

It is so easy to break the chain of technique in careless amalgam work; to ignore careful cavity preparation; to use an inferior alloy; to omit or misuse the matrix; to use an indifferent mercury-alloy ratio during a restricted period of trituration; to employ very little force in packing, using incorrect instrumentation; to fail to remove the excess of mercury; to overlook anatomical restoration and yet make a filling fairly presentable to the eye, but later to declare amalgam an inferior material because leaky margins appeared. All of these abuses are contributing causes of the prejudice against amalgam and unjustly so, because the fault was the operator's. The rules of a correct technique for amalgam filling are as *arbitrary* as those for the gold-foil filling or the gold inlay, but those for amalgam are more frequently and more ruthlessly broken and you know why. Contraction in amalgam is inexcusable and is principally inherent in such alloys as should be rejected, although it must be admitted that an amalgam which should show a slight expansion can be incorrectly manipulated to show contraction; but that is faulty technique.

Dentists have been responsible for some of the delay in the improvement of alloys and technique, for they have demanded and many still demand an alloy which can be triturated in a jiffy in the palm of the hand, after which it is pushed into the cavity without the use of a matrix and, as Hinman has said, "with our trade mark on it—skin markings." I designate this

as a modified Bertillon system for the future identification of their own work. The manner and length of trituration time is of great importance when using the improved alloys. This is another interesting point on which to enlarge. I am inclined to be prophetic in regard to mechanical mixing and I believe it will be one of the next developments in amalgam technique.

In order to draw this discussion to a close, may I briefly enumerate some instances where amalgam is especially indicated?

Its use is restricted to the posterior teeth with the possible exception of the first bicuspids. This exception is noted, however, for aesthetic and psychological reasons. Like the worthies of old, humanity today worships the golden calf and the color of gold has a psychological influence on the patient, as it represents intrinsic value to him. Gold also represents the aesthetic on account of the oxidation of former amalgam. It is true that yellow shades predominate in most teeth and I am prepared to admit that the contrast between them and gold may be even less than that of the amalgam filling I have in mind, in spite of its beautiful finish. So we will concede the first bicuspid to gold, if the restoration is not too extensive. In the remaining posterior teeth, particularly in the superior maxilla, I believe that the *larger the restoration* the *more amalgam* is indicated. Both the first and the second biscuspids on the lower maxilla are more visible than in the superior, and here again I frequently resort to gold if the restoration is not too extensive, particularly in the mouths of women.

You will observe that I am inclined to appease the wrath of the inlay workers and not stir up a hornet's nest about my ears, but I do wish you to consider carefully the point I make when I repeat—the larger the restoration the more amalgam is indicated. All of us have experienced difficulty with large inlays, particularly those of the m.o.d. type.

I am convinced, from my observation of the work done by the average dentist, that many of the very extensive gold inlays fail to fit accurately the margins of the cavity in their *entire peripheries*, which is largely due to the size of the restoration and the inability of the operator to control expansion and contraction in the processes of burning out the wax pattern and in casting the gold. In such cases, it is quite possible that a careful amalgam technique would result in a restoration which would fit the margins more perfectly in the entirety and give the longer service. I am aware of the beautiful work done by Gillett, the Tracys, and others in your city, and this is no criticism of such work, but I should be happy to see some of you develop the amalgam technique to the degree of proficiency to which you have developed that for gold. I trust I am not "treading on

the corns" of anyone by the implication that some of you have not attempted this. I have merely assumed that the type of work all of us are familiar with and condemn in amalgam has possibly been accepted as a criterion of what can be done. The message I particularly desire to bring to you tonight is the assurance that highly creditable results are possible with amalgam, inserted under a more correct manipulation than is commonly practised.

I am also firm in the belief that many pulpless teeth are condemned to wear gold crowns when the full amalgam restoration or amalgam crown so called, would be infinitely better and should return as large a fee. No one can deny that if it is possible to fit a band accurately for a gold crown, it is equally possible to fit a matrix for amalgam. When this matrix band is removed, a flush margin or joint is left, sanitary and agreeable to soft tissues, thereby eliminating some of the objectionable features of the gold shell crown. (Specimen exhibited.)

You will all agree that amalgam is indicated in a cavity which cannot be kept entirely free from moisture and is virtually the only material available for such cases.

Another type of case where amalgam is indicated is its use as a base for the foil filling or the gold inlay, even in anterior teeth, when cervical margins are presented well under the gum tissue. In these cases, amalgam may be used only to the degree of bringing the cervical wall up to the free margin of the gum and, at a subsequent sitting, used as the base or cervical wall for a gold restoration.

The length of my discussion reminds me that I must content myself with reference to these few specific cases. In conclusion, may I say that I do not wish to give the impression of making an overzealous use of amalgam in my own practice. I have great confidence in its use where indicated and employ it with the assurance of a reasonable degree of success. Each material has its place in dentistry and the essayist has treated the subject of "The Restoration of Individual Teeth," and the materials involved, with consummate ability. To my mind, the really skilful practitioner is the one who selects the material which will give a maximum service with a due consideration of his ability to use it in the case at hand. I am, however, more convinced than many that the alloys now obtainable, inserted under the details of a correct technique, afford the assurance of such a quality of service in amalgam work as to place it on a par with gold. If this be true, such a technique is worthy of the ***most skilful*** men in our profession, whether their practice is among an exclusive clientele or not.

J. W. Sherer, D.D.S. (*East Orange, N. J.*): It is indeed fortunate that the essayist in his opening paragraph likens his task of adequately writing on restorations of individual teeth, within the scope of an essay, to recording the history of the world on a thumb nail. He follows this statement with characteristic forethought by inviting those who participate in the discussion to extend their remarks over those phases of restorations that he has merely introduced. With this thought in mind, I will pass over that part of the paper treating the foil filling and amalgam restorations, by stating that I am in entire accord with every word it contains. I wish especially to compliment the essayist on his closing remark on the latter restoration: "Unfortunately, the observance of these rules (exacting details for good amalgam work) means an expenditure of time that may frequently equal, or in my estimation often exceed, the chair time required for cavity preparation and insertion of a gold inlay that will be of greater service."

As to the porcelain inlay, I confess frankly it has given me very meagre satisfaction. The application of this restoration is so limited and infrequent that that in itself detracts from the possibility of real proficiency and thoroughly pleasing esthetic results. Also when you consider the other factors, namely, cement line, proper blending of shades, lack of edge strength and light effects, you may complete the picture according to your own experiences.

The essayist in speaking of the silicate cements has stated the case of those materials most conscientiously. In my hands they have not proved sufficiently satisfactory, except in a few instances, to be considered a so-called permanent restoration. Where these materials are employed posterior to the cuspids in preference to the inlay, they may be conducive to great harm to the peridontium. The early disintegration of contact point and the breaking down in proximo-cervical region leave in their wake the usual hypertrophied proximal gingiva and if not corrected at once, may lead to the untimely destruction of that tooth. To place a silicate filling in a compound cavity of a molar or pre-molar has never found favor in my practice.

Individual teeth requiring restoration by means of artificial crowns are most ideally built up to form, function, and appearance, by well constructed porcelain jacket crowns. There is no service we can render a patient that is more appreciated or calls forth more favorable comment than this type of crown when all details of tooth anatomy, color, and finish, are faithfully reproduced. I shall pass over the evolution of the porcelain jacket crown from its humble beginning of fusing porcelain on to

a platinum shell and facing, to the more recent all-porcelain jacket which in reality may be called a replica of the enamel cap of a tooth. Most of you are familiar with the technic of preparing the tooth for the construction of a jacket crown resting on a narrow shoulder cut circumferentially on the gingival portion of the tooth. A later development in this field (sponsored by Dr. Le Gro of Detroit) calls for the omission of this shoulder preparation inasmuch as the shoulderless crown embodies several decided advantages over the other type. I need not repeat here that success with either type calls for the most accurate manipulation of which the operator is capable, with no slighting of detail. Short cuts have no place in this work.

I shall touch upon a few of the more important phases pertaining to the construction of a shoulderless jacket crown. It is a custom with me to trim the tooth to be jacketed except any of the six anterior teeth, only so far as I can without injury to the gingiva at the first sitting. A 28-gauge copper or aluminum band is quickly trimmed and festooned to pass slightly within the gingival crevice. The occlusal portion of the band is spun inward to avoid irritating tongue and cheek by any sharp edges. The tooth is wiped with eugenol, the fitted band placed upon it containing a stiff mix of oxid of zinc and eugenol and occasionally a little temporary stopping is added to the occlusal portion. When the patient returns this band is removed and it will be seen that the free margin of the gingiva flares away from the circumference of the tooth cervix, giving the operator the opportunity to note the character and amount of trimming to be done at this, the most important part of the tooth. Allow me to stop here long enough to say with all the emphasis at my command that any restoration, of whatever nature, can only be as good as that portion of it terminating in the gingival crevice. Therefore, the preparation of this region must now receive the most thorough and painstaking consideration.

With the various types of enamel scalers and cleavers, but principally with Evans root trimmers, the remaining gingival ridges are removed and made as smooth as possible, at no portion a suggestion of convexity remaining. You cannot spring a porcelain jacket over a faulty preparation as dentists were wont to do with the old-style gold crown. If undercuts exist, they must be eliminated. The prepared stump must present a picture of a tooth slightly tapering toward the occlusal, with its largest circumference at the lowermost portion in the gingival crevice, reduced on its occlusal surface sufficiently to allow for even thickness of porcelain, and all planes reproduced to meet occlusal stresses at right

angles. It is necessary that the operator examine the stump to see if it meets all these requirements. My procedure is the following:

The saliva is dammed off by cotton rolls, and the saliva ejector put in the mouth. The assistant cuts a small cotton roll, three-quarters of an inch long, lengthwise, saturates the halves with adrenalin chloride full strength, and holds them lightly on either side of the tooth against the gingiva with the thumb and first finger. Within from three to five minutes the mucosa surrrounding the tooth will be completely blanched. Dry cotton rolls are placed in the mouth, compressed air stream is brought into use, and a perfectly clear view of the entire preparation is the result. It is surprising how long the gingival crevice will remain dry when adrenalin has been employed. I always use it preceding cementation. If faults in the gingival preparation are discernible, they are now corrected. So far the steps are identical for either type of jacket crown.

To construct a shoulder crown, it becomes necessary now to cut this shoulder. It should be cut a minimum in width, should follow the gingival festoon below the gingival border, is often a most tedious operation to accomplish ideally, and is well nigh impossible for some. The cutting of this shoulder, it matters not how narrow, certainly calls for the removal of some extra tooth substance. This is not desirable. Consider also such teeth as present a pronounced bell-shape, like some of the lower bicuspids, and I think you will agree that the shoulder preparation may prove hazardous.

The next step of importance is to obtain an accurate impression of the shoulderless stump. The shoulder advocate will say, "To what do you finish your crown?" I will try to make that clear in the subsequent steps. A wire measurement is taken at the largest circumference of the stump. A copper band, 28-gauge, is fitted and festooned, with the fact always before the operator that the depth to which the edge of the band goes in the gingival crevice will be the termination of the porcelain crown. With the aid of the electric mouth mirror and compressed air, inspect the fit of the band. With a sharp scaler draw a line around just opposite the crest of the gingiva on the band. This mark is a guide when the modeling compound is pressed over the stump. After placing the compound in the band, be sure to stick it fast to the gingival edge with a hot spatula. Wipe the stump with eugenol; once more pass the compound cup over the flame and place it over the stump within one millimeter of the mark on the band. Now place a short broad stick across the occlusal end and press to place as far as the landmark on the band. Continue the pressure while a fine stream of cold water is played on the band. When thoroughly hard, use

a gauze napkin and remove with a straight pull. The cervical end of the impression is encircled with a ribbon of wax and pushed into a waxed-paper tube preparatory to embedding it in plaster. This wax collar will permit the amalgam model to assume the shape of a typical shoulder preparation, which is important, as will be seen later. When the amalgam is thoroughly hard, the band containing the impression is gently heated and separated, and the amalgam model wiped with chloroform. This amalgam shoulder is ground to 1 mm. in width and with a sharp, flat chisel, is planed with a slight bevel rootward. From then on the construction of the platinum hood is the same as for the shoulder crown, with the exception that the tinner's joint is disked to one thickness for the distance of from 1 to 2 mm. at the point where the joint meets the shoulder on the die.

The building up of the porcelain is the same for both crowns. The ditch at the shoulder is cut with a cataract knife prior to the first bake to allow the porcelain to shrink here. Before the second bake this ditch is filled in, and it is important that the porcelain is very thoroughly jarred to place. If the porcelain is not dense at this point you will not have a smooth, unbroken cervical edge to the finished crown. After the second bake the crown looks like a shoulder crown, but this porcelain shoulder is merely one of transition. It is for the purpose of providing strong porcelain at this point and to permit a change into the best possible reproduction of gingival ridges.

I wish each one of you would sit down at the first spare hour you have, with a variety of extracted teeth before you, and concentrate on the gingival termination of enamel. While your interest is aroused, make a cross section of a few of these teeth and note how rapidly the enamel becomes thickened, flaring out, as it were. It does not terminate gradually to a feather edge except in rare instances. If you carry this picture in mind, you are prepared to imitate this condition in the porcelain jacket. Dr. Le Gro advocates doing this with the crown on the amalgam model. I find that this does not work as well as would appear. I much prefer to hold the crown in my hand, which enables me to see when I have ground to correct contours. For this purpose I use first the S.S.W. mounted disk stone #33, followed by carborundum-paper disks of various grits. The crown is now ready to be tried in the mouth, the final corrections are made, and the third bake is conducted at this time to the finished glaze. The platinum hood is now carefully removed and the inner surface of the crown etched with hydrofluoric acid. This is thoroughly neutralized and the crown is then cemented in place.

The advantages of the shoulderless jacket crown as compared to the shoulder type are these:

(a) The shoulderless preparation is a safer procedure for the tooth.

(b) Due to the fact that it can be placed further under the free margin of the gingiva, its frictional area is increased—in other words, it has better holding quality.

(c) Inasmuch as the shoulderless crown terminates deeper within the gingival crevice, it is a more sightly restoration. I have seen shoulder crowns, especially on lower molars, with exposed joints.

(d) The preparation for it is not nearly as difficult, although just as exacting as for a shoulder crown.

It was a wise man who said, "You can learn nothing from a man's successes." Therefore I will tell you of the failures I have had and what caused them. Two crowns became loosened because the stumps were too short and tapered too much. Two others that were placed on pulpless teeth came away each bringing with it a fractured portion of the stump. This taught me always to build up that tooth substance that was removed to facilitate root canal operations, by means of inserting a platinous-gold post part way in the canal, around which was cast a gold inlay core. A cement core alone is not safe. One crown was broken in cementation. My cement, being mixed too stiff, hardened too quickly. I thought I would seat it with the aid of a husky stick and main strength, but I learned something right there. Two were broken from causes I could not determine, probably abuse or accident that a patient will sometimes keep to himself.

In speaking of the cast gold inlay for individual tooth restoration, the essayist reveals the fact that, having schooled himself in his earlier practice in the construction of the two-piece matrix gold inlay, it was the natural thing to follow along similar lines of reasoning which led up to his adoption of the indirect method of making his cast inlays. That this method has proved eminently successful in his hands, no one who has followed his teachings or been privileged to see his actual restorations in the mouth can doubt. That is the proof of the pudding!

If an operator makes the statement, "Better castings are made by the indirect than by the direct method," he may be absolutely right as far as he is concerned, but the fellow to whom this statement is addressed may have been equally busy for years developing the direct method to suit his practice. It may be entirely satisfactory in his hands, in fact may be so satisfying to him that he too may get fire in his eye and proclaim from society platforms, "The direct method of making cast gold inlays is superior to the

indirect method." This should not be so. Jim Smith says, "I made indirect inlays for years, but since I have mastered the technic of making correct wax patterns in the mouth, I would not think of returning to all the steps of the indirect method." Bill Jones says, "I once made all my inlays by the direct method but of late years all my inlays are made by the indirect method." So you may argue until teeth no longer require inlays. As far as I know, there is no data at hand for either advocate to prove that one method will beget a better result than the other. Good inlays made by either method, all other factors being equal, have not failed in the years I have observed them. When old patients return for examination, unless I consult my records, I cannot tell which method was used in making the inlay. I admit to having made something over three hundred cast inlays by the indirect method. That I have for years obtained all my wax patterns directly from the tooth is only because I was determined to master this particular step in the direct method, and for another reason —I have no skillful mechanic to bring my inlays to the chair finished and ready to be cemented.

The essayist makes the just criticism that some direct inlay workers have their inlays not quite flush with the cavity margins on proximal surfaces. I have noticed this too. In anticipating the criticism that may be made by some, that the indirect men use the overlapping inlay margin that tends to leave projecting gold margins under the gingiva, the essayist states, "This is true if the work be done carelessly, and is to be met and overcome just as any other tendency to defects is overcome. Its control is merely an incident to the careful operator." By the same token, any careful operator shaping a wax pattern in the mouth certainly considers the correct conformity of his wax to the margins of the tooth as merely an incident in his technic.

The cavity preparation having decided bevels, that the essayist speaks of, is not as recent as he states, nor confined to the indirect men. I brought that form of preparation over into my direct technic years ago. Whether this overlap can be produced more easily on the amalgam model than in the tooth is again a matter of the individual ability behind the instruments.

There is one point that I hope the essayist will make clearer in closing. I refer to the statement in criticism of the direct method, "It is my claim that the casting of an accurate fit is uncertain and doubtful, etc., more important still, that such an inlay is unnecessary, is a menace and is frequently detrimental to the teeth and to the patient's welfare."

To have had the privilege of studying this essay and of being invited to take part in its discussion, I consider a signal honor. In its pages are

woven the high ideals, thoughts and practices of a full life of service—SERVICE written in capital letters—of a man whose professional record we may all envy and try to emulate.

Dr. Gillett (*in conclusion*): The lateness of the hour, which has limited the discussion, also forbids any lengthy summing up. In reply to Dr. Baker, I desire to say that the method of obtaining separation is unimportant, except as it influences the comfort and conveniences of patient and operator;—the restoration of contact, with smoothness at the contact point, is imperative. If the procedure suggested by him accomplishes that end, and is less troublesome and more comfortable than wedging, it is commendable. It would seem to me to be limited in its application to the cases where but one filling at a time is to be inserted, because of the risk involved in applying the described packing force for a second filling against a matrix, in contact with the adjacent freshly-packed amalgam.

My objection to band matrices is the absence of contour form common to them—they tend to produce straight lines cervico-occlusally. A matrix should as nearly as possible reproduce the lines desired in the finished work.

I am in hearty accord with Dr. Baker's plea that a good amalgam restoration is far superior to a badly fitted shell crown, but I radically disagree with his contention that "the larger the restoration, the more amalgam is indicated," and the reasoning with which he supports it.

He is correct as to the frequency of mediocre results from the hands of mediocre operators pursuing the absurd policy of casting very large and complex gold restorations in one piece, but that same mediocrity will be manifest in the work of the "dub" operator, whether he attempts difficult work in the amalgam, or any other material. The socalled "average dentist" is too constantly accepted as a necessary incubus. I am restive under this assumption, and instead of being content merely to show him the easy way to do the supposedly simpler things, I am disposed to prod him into activity to avail himself of some of the many avenues of post-graduate work open to him, so he may move higher on the ladder of achievement and service.

In no other field are the superior results of the cast restoration so manifest as in the one Dr. Baker claims for amalgam, provided skill and care are used. Surely, in order to convince you of this, it is only necessary to remind you of the ready feasibility of first casting a base for such restoration, of using a gold soft enough to insure ability to perfect its margin of the typical over-lapping form, following this with a second casting of a

more resistant gold for completion of the contour and occlusion (hollow for the sake of lightness), and then of uniting the two with an appropriately colored solder.

No step of such a process is more difficult than those of the ordinary large inlay; there are merely more of them, and the support to the weakened tooth, because of the opportunity to utilize the principle of the cope, the perfection of marginal fit and sub-gingival contour, and the consequent gingival integrity, are far superior to the results attainable with very large and complex amalgam restorations. It is in just such restorations of masticating teeth, where two or more sides have been destroyed beyond the gingival margin and from half to all of the crown has been lost, that I have felt most sure of ability to make a cast reproduction insuring health of the associated vascular tissues, and the utmost in conservation of remaining sound parts of the tooth.

The further elucidation that Dr. Sherer asks for, of the sentence—"It is my claim that the casting of an accurate fit is uncertain and doubtful, etc., more important still, that such an inlay is unnecessary, is a menace and is frequently detrimental to the teeth and to the patient's welfare," seems to me to be readily found in my paper.

If the casting of such "absolute" reproductions of the wax model as are demanded by the advocates of frictional contact between inlay and cavity wall is not "uncertain and doubtful," why the reams of explanation in our dental literature as to how to overcome the difficulties of doing it? If such frictional contact is necessary, why do operators who disregard that requirement, but pay attention to the principles of sound mechanics in cavity preparation and gold selection (numbering in their ranks as they do, many of the ablest exponents of true service to their clientele), discover no unfortunate or detrimental results because of such disregard? If the thermal conductivity of cement is very much less than that of gold, is there any doubt that gold, in contact with the deeper parts of vital dentine, is a "menace and a detriment" as compared with cement in the same relation? If the success of both systems depends, as is apparently the case, on spinning the *margin* of their product to the nearest possible contact with the tooth as a means of protecting the cement from mouth fluids, of what importance are the painstaking efforts of the "glovelike fit" advocates to cast an "absolute" duplicate of their wax model made in an ultra-smooth cavity?

Obviously, in the technic of either system, it is easy to remove a layer of wax on the cavity side of the wax model and provide for the protective layer of cement at the points where it is needed. The desirability of so doing

being admitted, then, if the direct system advocate says, as does Dr. Sherer in effect: "I work by the direct system because it is easier for me, with the staff organization that I prefer, to produce good inlays by that system," I have no disagreement with him, provided he does actually produce *good* inlays. I have found it easier to develop proficient inlay workers by the indirect system, but I care nothing at all about which system a man uses, if, by that system, he provides his patients with inlays that restore correct tooth form, protect the integrity of the pulp and tooth, and have a marginal fit that insures permanency of the underlying cement, and the health of adjacent gingivae.

I desire to thank Drs. Baker and Sherer for their courtesy, and I appreciate the patience displayed by the audience at this late hour.

SOME CRITICAL STAGES IN THE EVOLUTION OF THE HUMAN DENTAL APPARATUS[1]

WILLIAM K. GREGORY, A.M., PH.D.

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You are all used to hearing papers from time to time in which the author turns aside from the technique of today and directs your attention to the long line of men who have contributed great discoveries and inventions each to the advancement of his special branch of science. But I shall invite your attention tonight to a series of nature's inventions that were all worked out millions of years before those recorded in human history. Each of these inventions was a signal and essential contribution to the art of mastication, and without them we should not be seated around this dinner table this evening.

At the present time we are in a period where people all over the country are denying the fact of evolution. Without stopping to argue the matter, I am going to attempt to sketch for you the great inventions of the past in a very brief time, with the purpose of showing what evolution actually is and has been. You doubtless know what the idea is, in a general way, but I want to show you the facts concretely. I cannot show you the evidence because that would take a long time, but I shall try to present some of these successive inventions in the evolution of the human dental apparatus in such a way as to omit speculative or doubtful features. I will endeavor to present the things which, in the judgment of those who are working on the problem, are not speculative but well founded.

Of the several leading sources of our information regarding the course of evolution there is first the testimony of the rocks. Here chapter after chapter of the earth's history is exposed. Geology then is the first basis of our knowledge of evolution. The record of the rocks, as generalized from the rock systems all over the world, gives us our geological time scale. The great subdivisions of the geological scale are marked by the successive upraising of the various mountain

[1] Read at a meeting of the New York Academy of Dentistry, February 21, 1923.

ranges. We should realize, of course, the order in time of the inventions which I am going to describe—not one earlier or later than its proper place, because the present always includes all of the past.

That is the first source of evidence of evolution and the second is the testimony of the bones themselves. Every animal has impressed upon its osseous system traces of the entire past history of its race. It is true that the later steps tend to obscure the earlier steps, but by patient analysis carried on by investigators all over the world, we can finally distinguish layer upon layer of these records which are imprinted upon the skeleton. In the skeleton of many species of whales are found the atrophied bones of the pelvis and of the hind legs. What other testimony would one want that these animals are descended from a land-living form that once had well developed hind legs? The visual record is there when you know how to read it and of course that is a matter of progressive constructive efforts, the same as in reading hieroglyphics. In palæontology we are tolerably assured of our principal readings because they fit one into the other. You learn to read one, and it opens up the other.

We often hear nowadays of the "*hypothesis*" of evolution. That is the word of a person who does not know the facts of evolution at first hand. Those who work on the material itself do not think there is anything hypothetical about the fact that animals do change in the course of geological time.

Next we have the testimony of systematic zoology. It may be said that it is often impossible to read an evolutionary story aright unless we take into consideration the broad classification of the animals whose structures we are studying. *Figure 1* gives at the left side the geological scale, and at the right the great classes of vertebrate animals and the ages at which they branched off one from the other. We are especially interested in man, who, as one of the latest branches of the mammals, appears in the geological record only a scant half-million years ago, a very brief time in comparison with the vast eons of the earlier geological periods. Suppose we are studying the origin of the teeth and we make a great jump directly from the conditions observed in man to those found in the sharks—why, we would be disregarding the plain teachings of systematic zoology. We must compare first the tooth forms of each smaller group and then go to the

next higher and so arrive gradually but surely at broad generalizations, and not jump all over the great tree of life as has been the all too prevalent fashion of comparative anatomists in the past. Thus the

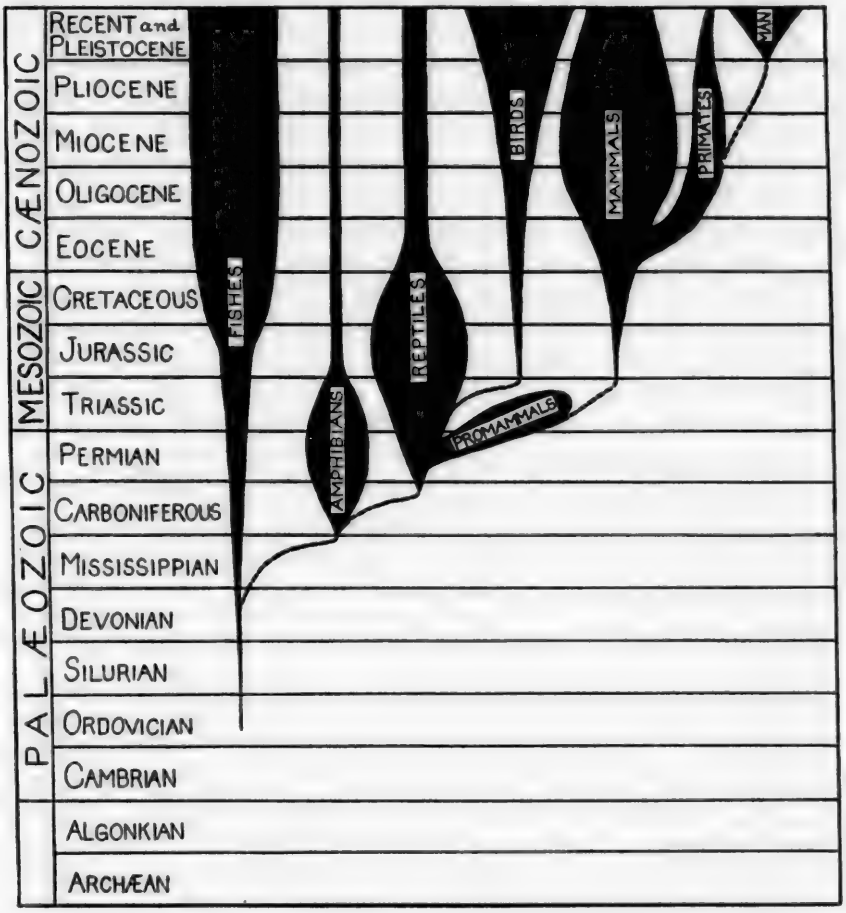

FIG. 1. Origin and rise of the five great vertebrate classes in geological time.

third great line of evidence is the evidence of the tree of life and of its innumerable branches among vertebrate animals.

Passing now to the main subject before us, the first and most im-

portant steps towards the acquirement of a head and of a masticatory apparatus we can infer only from those lowly animals that have come down to us unchanged through eons of time. If all structures observed among the animals of today were of equal age, then comparative anatomy could tell us nothing as to their sequence in time. But comparative anatomy is indeed futile unless its results are reached in connection both with the geological time record and with systematic zoology. From this combined evidence we learn that the first step towards the evolution of a head, taken among certain of the invertebrate animals, was the differentiation of a head end from a tail end; and that was associated with locomotion in a fore-and-aft direction. Radiate animals do not move in a fore-and-aft direction but the ancestors of the vertebrates took that step. What made them do that, we do not know. Possibly it was because they had to orient themselves with the movements of the tide. The flatworms have already gone well along on this line and have developed fore-and-aft movement, a head end and a tail end, together with a nervous system by which all parts of the animal are kept in touch with the other parts.

Now we come to the record of the rocks. Here (*fig. 2*) is one of the oldest known fishes, from the Silurian rocks of Norway; its age is relatively late in the entire history of the earth but early in the history of vertebrate life. These Ostracoderm fishes had already made a great advance upon their pre-vertebrate ancestors, whatever the latter may have been. Their adaptations for moving in a fore-and-aft direction were already well established. They also had a well developed exoskeleton but their endoskeleton, if present, was still unossified. In hundreds of well preserved specimens of these Ostracoderm fishes we never find any evidence of either an ossified or a calcified endoskeleton; so that step had not yet been attained. They had also taken on the vertebrate method of locomotion by means of serially arranged muscle segments on each side of the body, as is shown by the arrangement of the scales on each side. That method of locomotion and its associated structure constituted a fundamental invention which has been inherited by all vertebrates since then.

The Ostracoderms must have had a system of connective tissue septa between the muscle segments, the same as in the modern fish, in which the myotomes are arranged in zigzag series separated by

connective tissue septa. That is the foundation for the endoskeleton of later forms. Thus it is to the lowly Ostracoderms that we owe the ground plan of the whole locomotor apparatus. This had already been invented far back in the time of the Silurian Ostracoderms.

Now we come to the next later period of the age of fishes (Devonian), and we find certain sharks which had taken another great step in advance. Their several inventions were, in fact, of the greatest importance. First they had invented a functional backbone consisting of metamerically arranged rods called neural and hæmal arches, lying above and below the notochord, which were the predecessors of the true backbone of annular cartilages and blocks. Another important thing that the predecessors of the primitive sharks had done was to develop a system of paired sense organs surrounded by cartilage, which formed the rudiments of the endocranium. The olfactory

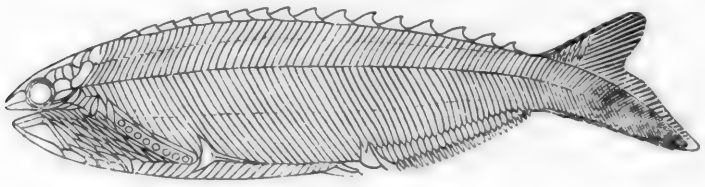

FIG. 2. Reconstruction, based on well preserved fossils, of an Upper Silurian ostracoderm, *Rhyncolepis parvulus*. After Kiaer. × 3/2.

capsules, the optic capsules, and the auditory capsules were disposed in pairs in an antero-posterior series. This arrangement was fully established away back in the age of fishes and it was of critical importance as it determined the location of the main centers of ossification when, after long ages, that process began.

Another invention to be credited to the early sharks was that of the primary jaws, which they had adapted out of the anterior gill bars of an earlier stage. The respiration being by gills necessitated the development of a jointed cartilaginous framework to support these gills. There is cumulative evidence to show that the primary jaws are truly homologous with these cartilaginous bars that support the gills; also that the jaw muscles which are inherited by us even at the present time are homologous with certain adductor muscles of the gill

arches. That is the basal patent for the later vetebrates. *Figure 3* shows the head of a recent shark, in which you will notice the great similarity of the jaws to the gill arches.

The sharks made another primary invention. They were the first inventors of true teeth, the same as those we carry in our own jaws. Here was another change of function. They took these little teeth which covered the skin of the body for protective purposes and they enlarged those in the skin that covered the jaws. The sharks were ruthless predatory animals and in pursuit of their nefarious profession they invented this means of robbing their neighbors. The denticles of the skin then were the forerunners of the dental apparatus of all later forms (*fig. 4*).

Now we come to the ganoid fishes, which represent a higher grade

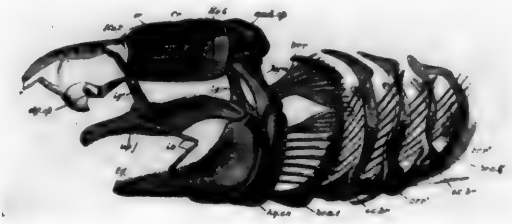

FIG. 3. Cartilaginous skull, jaws and branchial arches of a shark (*Scyllium*). After Parker and Haswell.

of organization than the sharks. They greatly improved the exoskeleton by fusing innumerable small denticles into tracts covering different regions of the skull. These fused denticles are the ultimate basis of the derm bones of our own skull. From similar aggregations of microscopic denticles they also developed scales covering the body. These fishes were called ganoids on account of their shiny armor and they made many notable improvements pointing towards the modern fish type. But those ganoids that were most progressive toward the modern fish type and are technically called actinopterous, or ray-finned ganoids, were the farthest away from our direct ancestors.

There was another contemporary series of Devonian fishes that appears to be closely related to or identical with our direct ancestors and these were the crossopterygian, or fringe-finned or lobe-finned, gan-

oids. The pectoral and pelvic fins in the more primitive of these fishes had a broad fleshy base (*fig. 5*), the skeleton of which seems to form the starting point for the evolution of the five-toed extremities of the earliest land-living animals. There is, in fact, a good deal of evidence for the view that some ancestor of these lobe-finned fishes gave rise to the first amphibians. As we look at a modern amphibian and at this ancient fish, we may say that they are quite different in appearance and one would at first be skeptical about such a transformation; but

FIG. 4. Head of a shark (*Chlamydoselachus*), showing the transition from the denticles of the skin to the teeth on the jaws. After Garman.

if one examines the facts available, one will find that the early amphibians inherited many characteristics from their fish ancestors.

The first primary invention that was made by the lung-fishes and some of the lobe-finned ganoids was the lung, a gland in the pharynx which appropriated the air dissolved in the water and finally the air directly. Thus the early lung-fishes had two bows to their string; if the water was fresh they breathed with their gills, but if they got into foul water where the oxygen supply was bad, they could come to the surface to gulp air and breathe by means of this lung. That was a fundamental invention.

Their next invention consisted in transforming their fleshy pectoral and pelvic paddles into limbs; and that was indeed no small task. Sometimes experimental zoologists tell us palæontologists that we cannot arrive at safe conclusions because we cannot subject our specimens to experimental tests. We reply that nature has been doing that for us on a vast scale and we need only to observe her results. In the case under consideration nature has provided us with animals that have remained in the old environment, while other animals under changed environment have changed their locomotor apparatus. One fish, for example, the *Periophthalmus*, or Mud-skipper, hops on the mud flats and even climbs up the roots of the mangroves by simply turning downward his pectoral fins, thus de-

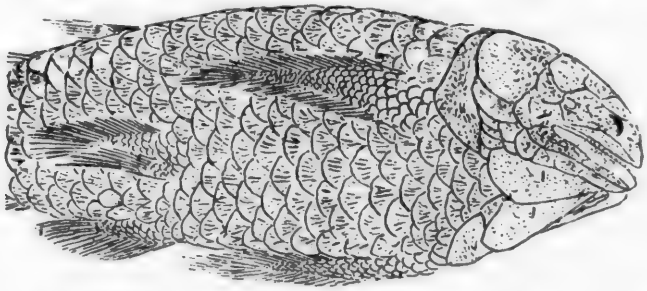

FIG. 5. A lobe-finned ganoid, or crossopterygian, *Glyptolepis macrolepidotus*, from the Middle Devonian of Scotland. After O. Jaekel. Fore part of the body viewed obliquely from below, showing the pectoral and pelvic fins.

veloping an elbow bend. But he is only trying this experiment on a small scale, while millions of years ago our direct ancestors did it on a large scale.

The Australian lung-fishes have elaborated their paired fins and they can use them as limbs to a certain extent. They can drag themselves along but not very effectively, for they still live in the water. Some of the crossopterygian ganoids of Devonian times had the type of fin you see here (*fig. 6*), in which the supporting cartilages were of a fan-like character. There was a single proximal piece corresponding to the humerus and a pair corresponding to the radius and ulna, while the more distal segments may correspond to the carpals and digits. But it must be admitted that the difference from a

true hand is still considerable, because these paired fins were used chiefly for paddling in the water. The earliest amphibians doubtless made great efforts to support themselves on these fan-like fins and were thus in seasons of drought able to crawl around from one water-hole to another, living half on land and half in water as some of the living amphibians do.

The first amphibians also effected several fundamental changes in the skull. *Figure 7* shows the roof of the dermocranium of one of

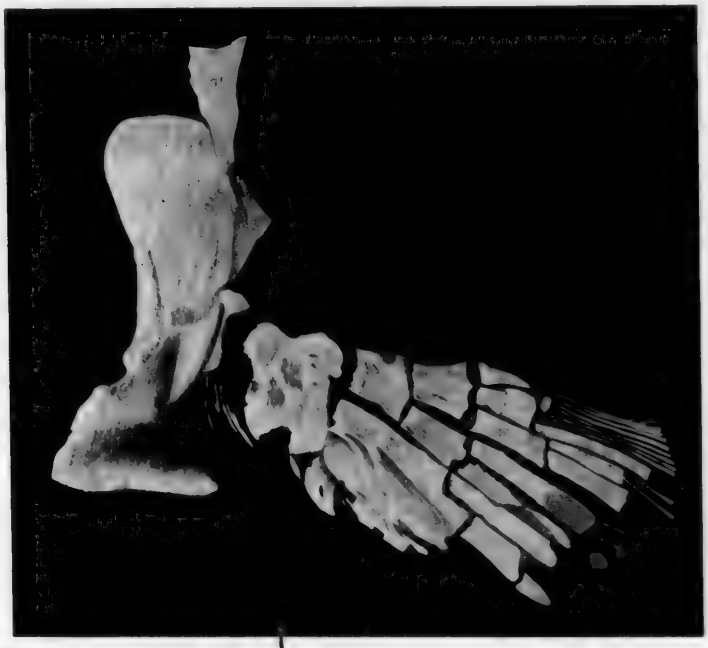

FIG. 6. Right pectoral limb of *Sauripterus taylori* from the Upper Devonian of Pennsylvania. After Gregory. One-third natural size.

these earliest amphibians. When you look at its plan you find that the early amphibians have every dermal skull element that we have and also many that we have long since lost. They have all these human bones—and the names were not arbitrarily given, since any one of these bones may be followed up step by step from the earliest amphibians to our own condition.

The lobe-finned ganoids had an elaborate system of derm bones covering the gills. When they came out on land apparently this system was not needed, because the amphibians inherited every one of their skull bones from their lobe-finned ancestors except the opercular series. Here (*fig. 8*) just behind the jaws is the place where the bony covering of the gills was lost. At the same time the later

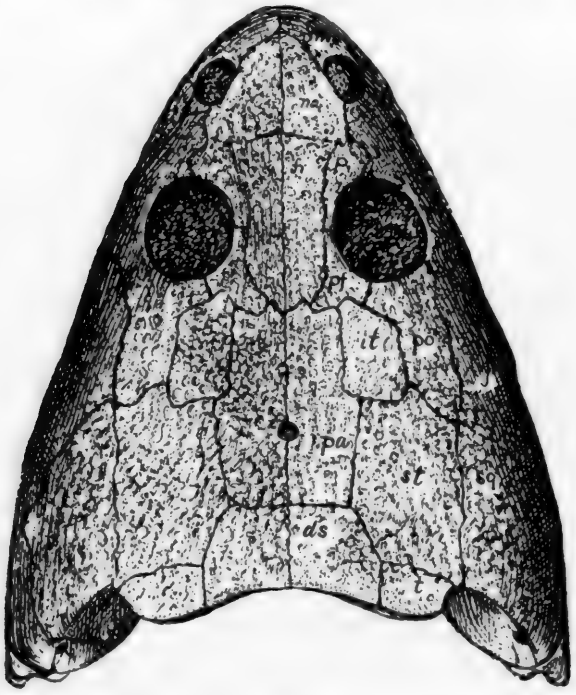

FIG. 7. Skull roof of a primitive amphibian (*Trimerorhachis*) from the Permian of Texas. After Williston. × 2/3.

amphibians lost the piece that connected the bony shoulder girdle with the back of the skull.

The lobe-finned fishes had a relatively large number of elements, considerably over one hundred, in the dermal cranium and attached opercular and mandibular series, while the higher vertebrates have a diminishing number that falls as low as twenty-two in the case of the

human skull. The effort has been steadily toward simplifying the skull and at the same time differentiating it. One finds thus that the diminishing number of elements coming through to later times become less and less alike.

The lobe-finned ganoids also invented an improved method of

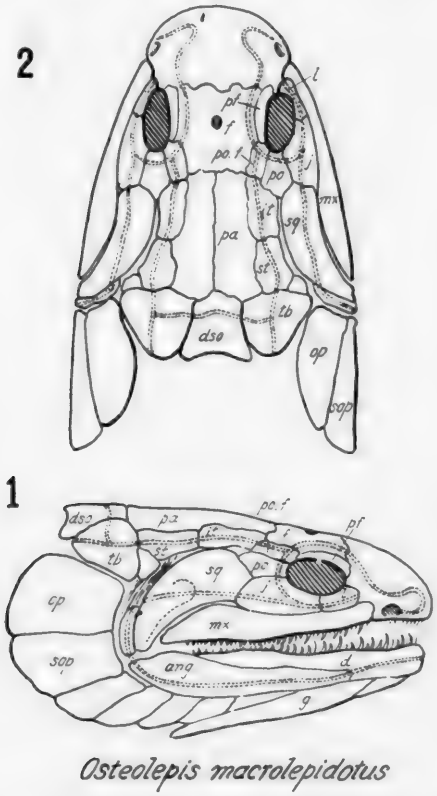

FIG. 8. Skull of a primitive lobe-finned ganoid (*Osteolepis macrolepidotus*) from the Devonian of Great Britain. After E. S. Goodrich. Showing the opercular series (op. s. op., etc.) covering the gill chamber. This system of elements was lost in the predecessors of the amphibia.

fastening the teeth on to the jaw. The sharks had a very poor method, the teeth being attached simply to the tough skin. But in the lobe-finned ganoids the whole side was deeply infolded at the base and

there was superimposed a secondary set of folds. At the same time the alveolar wall became involved in these folds, especially at the base. This is called the labyrinthodont type of tooth from the fact that it was first known to science in the ancient labyrinthodont amphibians, but the device was certainly older than the amphibian stage and was, in fact, perfected by the lobe-finned ganoids. *Figure 9* illustrates sections of the teeth of a lobe-finned ganoid showing the original way of fastening the teeth to the jaw.

In this view (*fig. 10*) of the palatal surface of the upper jaws you will observe that this lobe-finned fish had two sets of elements in the upper jaw, an outer set, the premaxilla and maxilla, and an inner set corresponding to the primary jaws of sharks, and comprising the palatoquadrate cartilage and its covering derm bones. This arrangement was transmitted by inheritance to the amphibians.

Thus in passing from the lobe-finned ganoids to the amphibians, the great advance was not at all in the structure of the skull but chiefly in the locomotor apparatus and in the lungs, so that the animals might live on land.

Here (*fig. 11*) are views of the complex lower jaw of one of the lobe-finned fishes, which consisted of an inner cartilaginous core homologous with the cartilaginous jaw of the shark, and an outer sheathing of numerous derm bones. This jaw has practically the same arrangement of the dermal elements that we find in the most ancient amphibians. The section of the skull roof of one of the ancient lobe-finned ganoids shows how the minute denticles are clustered together around the underlying cartilage bones. The bony skin thus covers the cartilaginous part and forms the outer or exoskeletal part of the skull. The secondary or surface jaws thus evolved in the lobe-finned ganoids were inherited by all the higher vertebrates.

Here (*fig. 12*) are some of the ancient amphibians, bold pioneers that first invaded the land for at least part of their lifetime. From their structural resemblances with recent amphibians it is probable that they all developed in the water after the fashion of frogs and newts. You will notice that in this group of restorations of the Carboniferous period there are different grades of specialization. *Eumicrerpeton* represents the most primitive kind, called branchiosaurs from the fact that the larval stages were provided with fish-like gills. *Ptyonius*

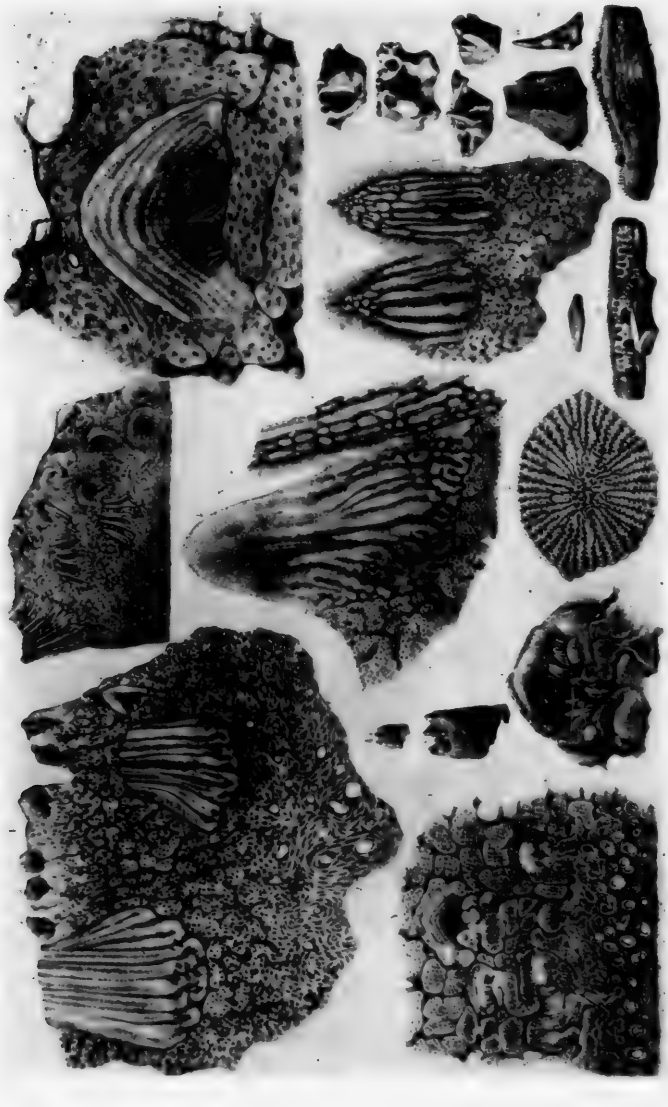

FIG. 9. Sections of the teeth of a lobe-finned ganoid, *Dendrodus*, from the Devonian of Russia. After Pander.

represents an aquatic type. *Amphibamus* is another type, which was better adapted for living on land. Then there are numerous "freak" types such as *Diplocaulus*. In the Carboniferous, as in every other age, one can readily distinguish in any great group several different

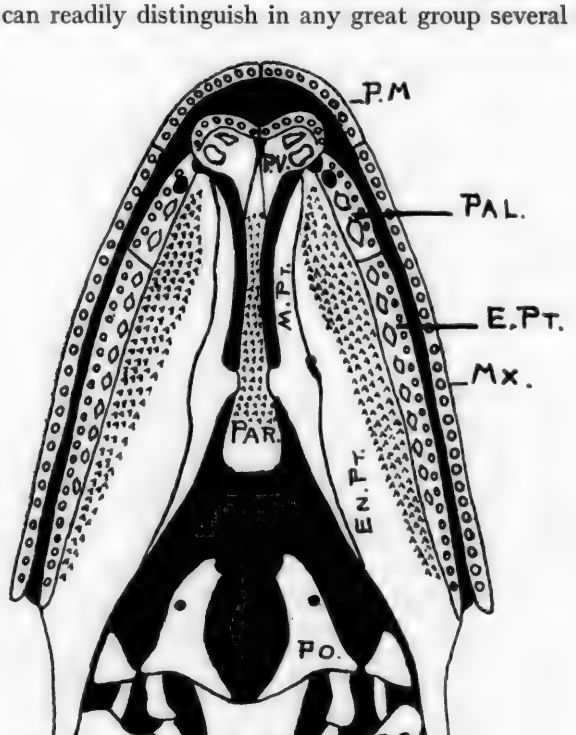

FIG. 10. Palatal aspect of the skull of a Devonian lobe-finned ganoid (*Eusthenopteron foordi*). After Bryant.

grades of evolution, which may be called the ultra-conservatives, the conservatives, the progressives, and the freaks. As a rule the progressives go ahead toward the next higher type but the freaks eventually drop out.

The amphibians, which were the first dominant types succeeding

the fishes, doubtless inherited the tad-pole method of development from their lobe-finned ancestors. Then we come to the primitive reptiles, which succeeded in getting rid of the water stage of development and could develop completely on dry land. Otherwise there were comparatively few differences in the skeleton between the oldest reptiles and the oldest amphibians.

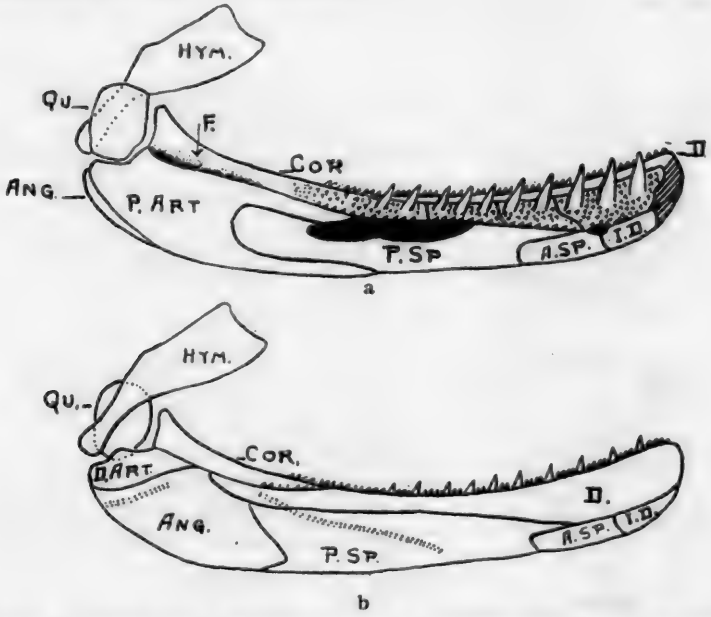

FIG. 11. Lower jaw of *Eusthenopteron foordi*, a crossopterygian ganoid from the Upper Devonian of Scaumenac Bay, Quebec. The primary lower jaw (Meckel's cartilage) is completely covered with derm bones, which are severally homologous with those of the earliest tetrapods. The teeth are of the labyrinthodont type and are limited to the dentary and the coronoid series. After Bryant. Upper figure (a), inner side; lower figure (b), outer side. *F*, mandibular fossa (for the insertion of the jaw muscles); *D*, dentary; *Cor*, coronoid series.

The reptiles took over the equipment by which the animal could drag itself along with the belly very near the ground. It was a kind of rowing on land, in which the ends of the oars were bent on the ground and the body swung between them. But there was a certain progressive type of reptiles (*fig. 13*) developed in the arid Permian and

Triassic ages in South Africa, which were not satisfied with this. They learned to run with their legs more under the body and that involved a great change in many parts of the skeleton. In this progressive member of the ancient mammal-like reptiles the locomotor apparatus was beginning to resemble that of mammals.

The same is true of the whole skull and masticatory complex. These mammal-like reptiles invented the method of fastening the

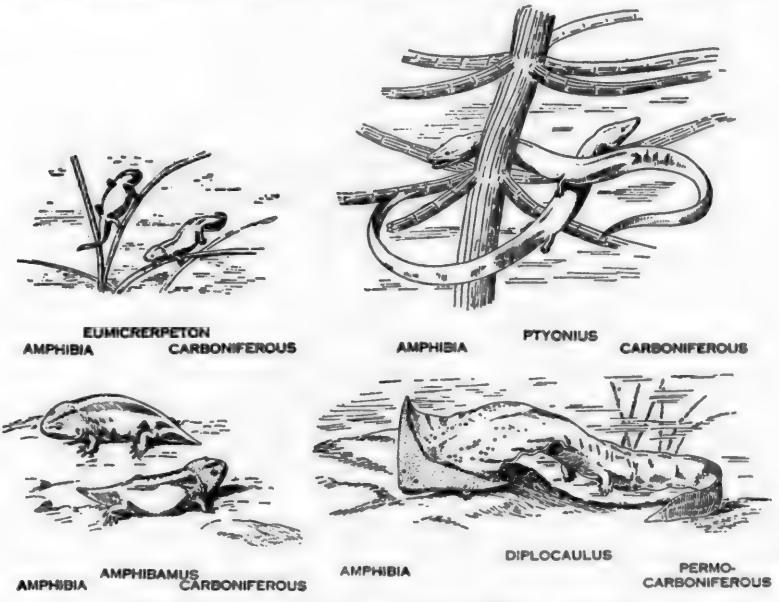

FIG. 12. Ancient Amphibians of the Carboniferous age. *Eumicrerpeton*, conservative; *Ptyonius*, highly specialized, almost snake-like; *Amphibamus*, progressive; *Diplocaulus*, depressed, bottom-living, a "freak" type.

teeth to the jaws by means of sockets, as opposed to the older method of having the enfolded bases interdigitating with the bone. They also tended to differentiate the incisors, canines, premolars, and molars. The upper jaw overhung the lower jaw and the upper alternated with the lower in a zigzag line as in mammals.

The mammal-like reptiles also effected some great changes for the purpose of strengthening the base for the jaw muscles. The primitive jaw muscles of the sharks were probably only enlarged adductor mus-

cles, like those that adduct the gill arches, and they were wrapped about the posterior ends of the primary jaw cartilages. In the earliest land-living animals, as well as in the lobe-finned ganoids, the jaw muscles were attached to the under side of the bony skin, or dermo-cranium covering the temporal region.

By the time of the early forerunners of the mammals the temporal skull roof was constructed in such a way that the strips of bone around the periphery of the temporal muscles were strengthened and enlarged, while toward the middle of the insertion areas the bone became very thin and finally vanished entirely. In this way the temporal fossa was formed by the absorption of part of the temporal roof (*fig. 14*). This improvement had a great bearing on all subsequent development of the masticatory apparatus in the higher vertebrates.

Next we come to the higher mammal-like animals of the Triassic age of South Africa. In studying the skulls of all vertebrates we find that the openings or vacuities in the skull are of as great functional importance as the bones themselves. For example, the orbit is fully as important as the bones surrounding it, and all the bones of the orbital and temporal region are modelled in conformity with the structures that fill these openings, namely, the eye and the temporal muscle mass. It is the form and activities of the temporal muscle mass that have moulded parts of the squamosal, malar, and postorbital into a

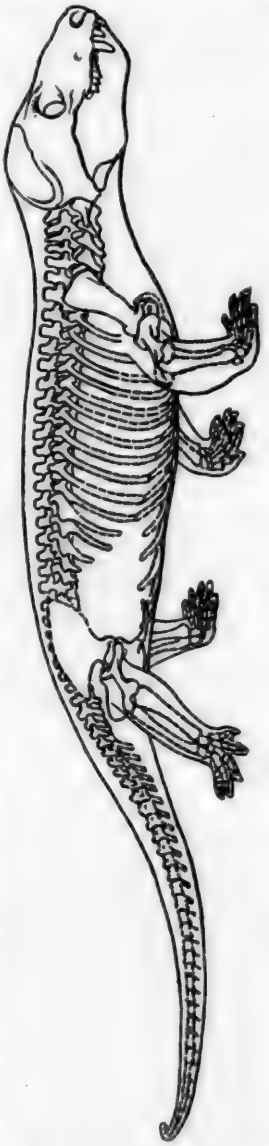

FIG. 13. Restoration of the skeleton of a mammal-like reptile (*Cynognathus*). After Gregory and Camp. × 1/14.

zygomatic arch, as we see in this mammal-like animal of the genus *Glochinodontoides* (*fig. 15*) from the Triassic of South Africa. Its skull was almost like that of a mammal but it was still technically in the reptilian class because it had not yet acquired certain important mammalian characteristics, such as the articulation of the mandible with the squamosal by means of a condylar process of the dentary bone.

In these extinct mammal-like reptiles we observe a very decided approach to the mammalian grade of organization. Before these mammal-like reptiles became widely known outside of the limited palæontological circle, comparative anatomists were led into all sorts of misleading results in attempting to trace the evolution of the

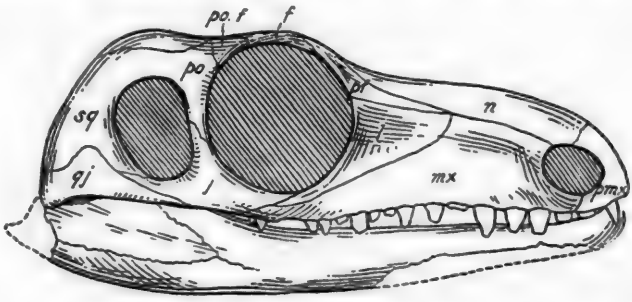

FIG. 14. Skull of a primitive theromorph reptile, *Mycterosaurus*. After Williston. × 1.

mammalian jaws, because they were not dealing with the animals that give rise to the mammals, but had to depend upon whatever they could get by comparing the construction of the jaws in existing reptiles and mammals. A study of these ancient mammal-like reptiles has entirely cleared up the origin and main lines of evolution of the mammalian lower jaw, as we shall presently see.

In the primitive reptiles the posterior nares were in the front part of the skull just below the anterior nares. But the mammal-like reptiles also made improvements in the respiratory system, necessitated by their life as active carnivorous animals. This we infer from the fact that they had a secondary bony palate (*fig. 16*) with the posterior nares behind it, as in the mammals. Thus in all fundamental

respects their palate was comparable to ours. Possibly also they had the beginnings of a diaphragm in connection with their improved

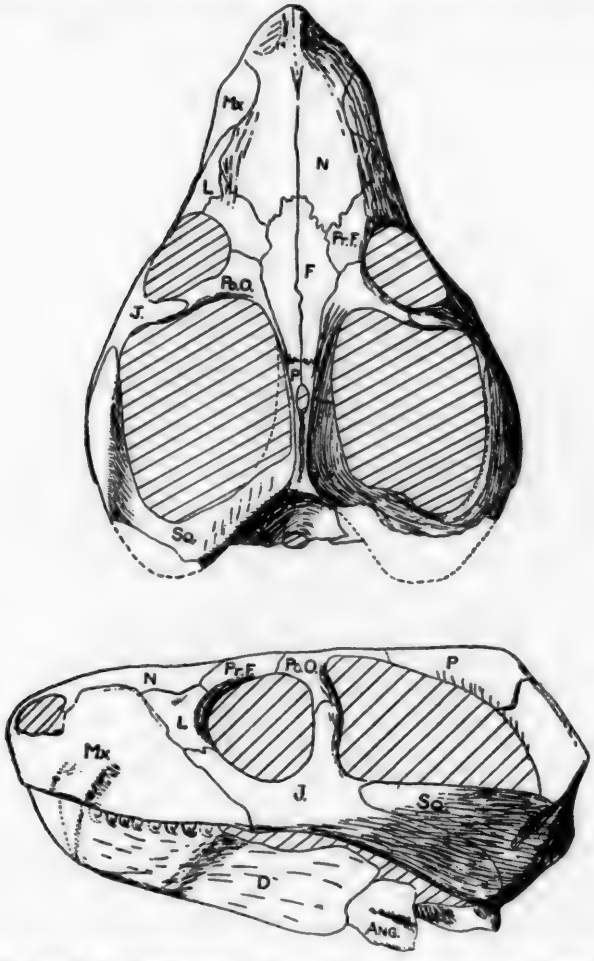

FIG. 15. Skull of *Glochinodontoides gracilis*, a small mammal-like reptile from the Upper Triassic of South Africa. After Haughton. × 1.

respiration, as we may infer from the marked differentiation of the dorsal and lumbar regions of the body.

nother indication of the more active metabolism of the mammal-
e reptiles was that some of them had attained pronounced regional
ifferentiation of the dentition. As I said above, these mammal-like
reptiles made great improvements in the construction of the lower

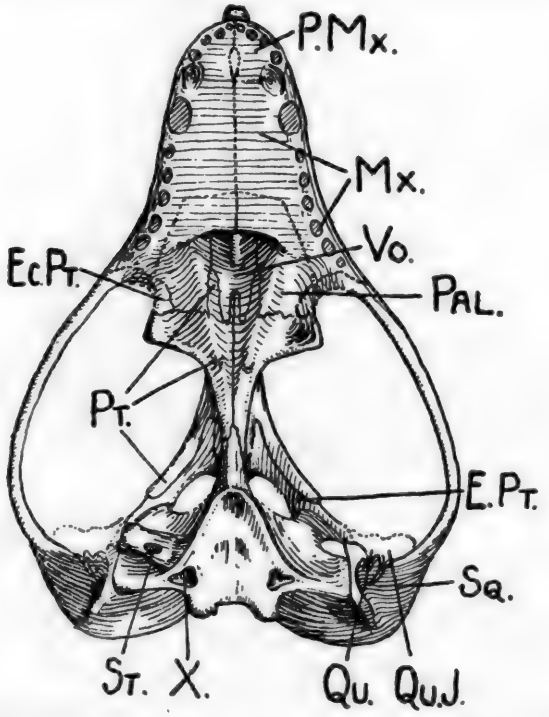

Fig. 16. Under side of the skull of a small mammal-like reptile (*Thrinaxodon liorhinus*) from the Triassic of South Africa. After Watson. × 1. Shows the mammalian type of palate and the double occipital condyle as in mammals. Among reptilian features are the retention of an ectopterygoid bone (ec. pt.), the large size of the pterygoid and the retention of the quadrate (qu.) as the main joint between the lower jaw and the squamosal.

jaw. In the earlier members of the group the dentary bone was not very different from that of most reptiles, but in the more advanced stages it was differentiated into a horizontal part supporting the teeth and an ascending ramus for the insertion of the temporal muscle

mass. Some of them have a jaw exceedingly like those of primitive mammals (*fig. 17*).

The separation of the dentary bone into two parts, a supporting dental part and a muscular ascending ramus, gave a handle or lever to the jaw, but it also undoubtedly restricted that part of the temporal muscle lying between the new ascending ramus and the surface of the squamosal bone; there is evidence that this interference of the ascending ramus with a portion of the temporal mass was adjusted by the formation of a bursa or cushion between the region of the future condyle of the jaw and the anterior surface of the squamosal. Thus

FIG. 17. Skull of *Trirachodon*, an advanced mammal-like reptile from the Upper Triassic of South Africa. After Seeley. × 1.

the later mammal-like reptiles began to invent a new joint, called the temporo-mandibular articulation, between the squamosal and the dentary bone. This sharply differentiated them from modern reptiles which continue to use only the older articulation lying between the quadrate and articular bones; but at the same time it allies them with the mammals, in which the temporo-mandibular articulation is predominant and the quadrate-articular joint becomes of vestigial size and is represented only in the cog-tooth articulation of the incus and malleus, which are the reduced representatives of the quadrate and articular bones of reptiles (*fig. 18*).

Even in the earliest reptiles the function of hearing was closely associated with that of mastication. There is evidence tending to show that the tympanic membrane was located just behind the quadrate-articular joint. But that is a whole chapter in itself. Let us centre attention on the anterior half of this masticatory-auditory

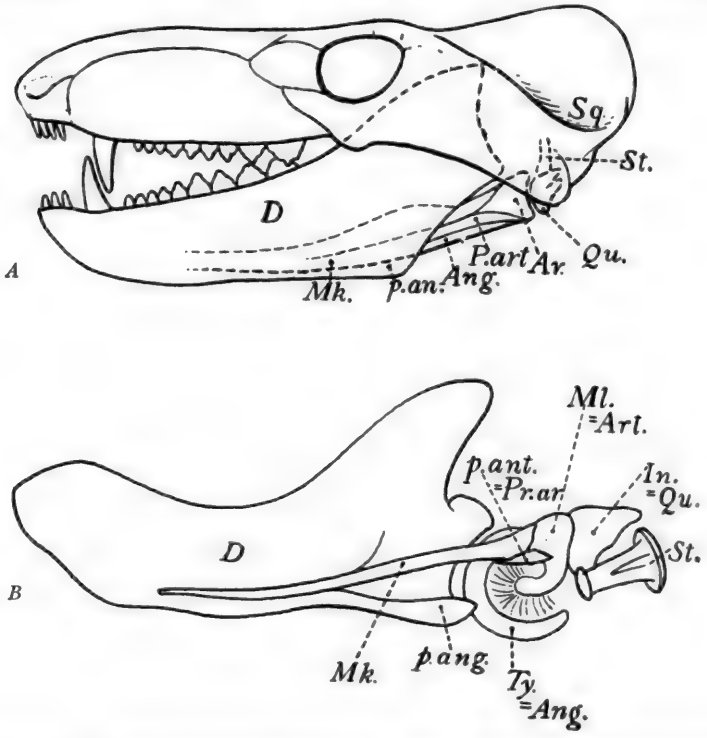

FIG. 18. *A*.—Outline restoration of the skull of *Cynognathus platyceps*, showing the dentary bone (D) differentiated into an alveolar portion, or corpus mandibulæ, and an ascending ramus; also showing the reduction in size of the posterior jaw elements (articular, angular, etc.) which in more primitive reptiles are of large size and form the sole joint with the upper jaw through the quadrate bone.

B.—Lower jaw of mammalian fetus (*Macropus*, after Benseley), showing resemblance to reptilian condition.

complex. In order to attain the mammalian condition the only remaining step was to squeeze down the cushion between the ascending ramus and the squamosal, so that it afforded a tough but elastic pad

between them. From embryological evidence it was the conclusion of Gaupp that the meniscus, or interarticular disc, has arisen from the squeezing down of that portion of the temporal muscle-mass which gives rise to the external pterygoid muscle. He noticed that the embryonic condition in certain mammals furnished an ideal transitional stage in the development of the meniscus, but he could hardly have anticipated that the conditions in the extinct mammal-like reptiles, to which he had until that time paid no attention, would afford strong confirmatory evidence from the palæontological side. Indeed Petronievics has reported that in certain of these reptiles he found a depression in the squamosal bone just behind the posterior corner of the ascending ramus of the dentary and in the precise position where an incipient meniscus might be expected.

The early reptiles had many series of teeth like the modern reptiles, but as shown by several specimens the mammal-like reptiles had succeeded in limiting the succession of the teeth to two sets, as in mammals.

The links between the mammal-like reptiles of the Triassic age and the true mammals we do not know. There is a long stretch of geological time when the dinosaurs were prominent, in which we find only a few jaws of very small mammals. But while this hiatus prevents us from tracing the exact steps by which the mammal-like reptiles became differentiated into the various ancestral lines of monotreme, marsupial and placental mammals, it does not conceal from us the broad process of the origin of the mammalian stem, which occurred at a still earlier epoch, probably not later than mid-Triassic times.

The basal patent in the origin of the mammals from the mammal-like reptiles is, I think, a simple one, although the mechanism is very complex; it is the development of a steady body temperature, as compared with a variable body temperature. Broadly speaking, the reptiles get cold when the weather is cold and they get warm when the sun comes out. But the mammal is notably independent of exterior change. There are all sorts of devices for regulating and keeping the body temperature relatively constant in mammals. The hairy covering and the numerous glands of the skin are only two of the wonderful devices for keeping the body temperature constant.

The mammal also conserves its energy, is able to appropriate more energy from its environment and lives at a much faster rate than the

reptile. One by-product of the transformation of sluggish-moving reptiles into active mammals is seen in the facial region. In the lower vertebrates the osseous mask covering the face lies immediately beneath the skin, but in the mammals the facial musculature lies between the skin and the underlying derm bones. Ruge, a great comparative anatomist, came to the conclusion that the whole mimetic or facial musculature of mammals had been derived from the platysma and sphincter colli layers of the lower vertebrates; that these muscles had spread forward between the skin and the underlying facial bones and had become subdivided into the mammalian facial muscles carrying the facial nerve from its primitive territory behind the ears and subdividing it into small branches supplying the facial muscles. No doubt the development of the facial muscles was not without effect

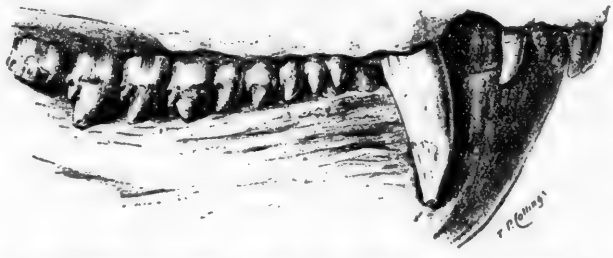

FIG. 19. Differentiated dentition with shear-like teeth of *Cynognathus*, a mammal-like reptile (cynodont) from the Upper Triassic of South Africa. After Seeley.

upon the masticatory apparatus, especially in so far as it contributed to the development of a muscular vestibulum, or buccal cavity.

We have seen that the higher mammal-like reptiles had the dentition differentiated into the same groups of teeth that are present in our own jaws, namely, incisors, canines, premolars and molars. In those days there was a simple shearing action of the teeth, as the upper overhung the lower (*fig. 19*).

After the development of a new temporo-mandibular joint and the reduction of the posterior jaw elements, the remaining steps leading from the primitive mammalian condition to that which is found in the human jaws today are comparatively simple and may be broadly summarized as follows:

First, the simple shear-like cheek teeth of the mammal-like reptiles became triangular in cross-section, the triangles of the lower teeth wedging in between the triangles of the upper.

Second, the posterior base of the lower triangles developed a small backwardly-directed process called a talonid, which engaged with a

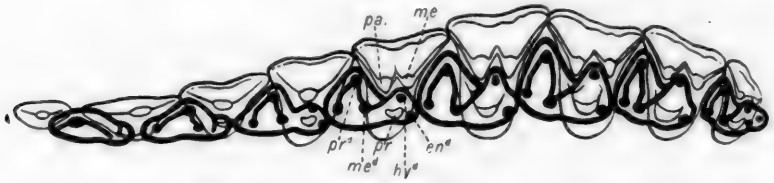

FIG. 20. Diagram illustrating (1) the probable mode of origin of the molariform patterns of primitive placentals, and (2) the correlated evolution of upper and lower teeth. Successive stages are shown in passing from the simple anterior premolars, which have only the primary trigon, backward to the molars, in which the secondary trigon arises through the inward growth of the "protocones" and the division of the primitive apex into two cusps, the para- and the metacones. This hypothesis is based on indirect evidence and awaits direct palæontological confirmation, as the upper molars of the oldest known placental mammals of the Paleocene had already acquired the secondary trigon in the upper, and the expanded talonid of the lower, molars.

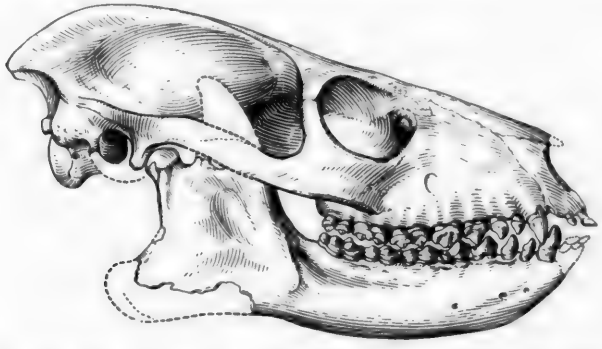

FIG. 21. Skull and lower jaw of *Notharctus osborni*, a primitive primate from the Middle Eocene of Wyoming.

similar process growing from the *inner* side of the upper teeth, thus initiating the famous "tritubercular" upper molars and tuberculo-sectorial lower molars (*fig. 20*).

Third, there was a marked reduction in the number of the postcanine

teeth from about ten to seven, the reduction affecting only the more posterior molars and being associated with a shortening of the whole face.

Fourth, a further shortening of the face was accompanied by a

FIG. 22. Upper and lower teeth, in occlusion, of (1) *Pelycodus trigonodus* (Amer. Mus. No. 15017, Lower Eocene, Wyoming) and (2) *Notharctus crassus* (Amer. Mus. No. 11982, Middle Eocene, Wyoming). × 3. (Inner side.) In the older and more primitive species, *Pelycodus trigonodus*, the pseudo-hypocones, or postero-internal cusps of the upper molars, are but poorly developed; thus the interdental embrasures are not restricted and receive the greater part of the trigonids of the lower teeth. In the later species, *Notharctus crassus*, the pseudo-hypocones are fully developed, encroaching on the interdental embrasures and articulating with the paraconids of the lower molars.

reduction and finally by the elimination of the first two premolars, so that in all the Old World monkeys and anthropoid apes the dental formula is reduced to I $\frac{2}{2}$ C $\frac{1}{1}$ P $\frac{2}{2}$ M $\frac{3}{3}$, the same as in man.

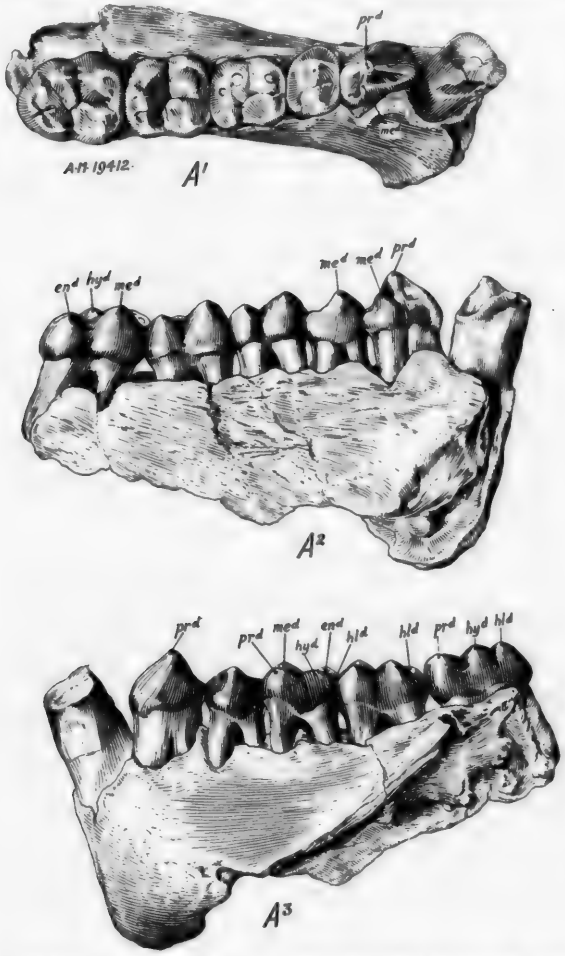

FIG. 23. Left lower cheek teeth of *Dryopithecus cautleyi* from the Miocene of India. × 1. Showing the five main cusps of the lower molars, homologous with those of primitive human molars. Also shows the "*Dryopithecus* pattern," traces of which are retained in primitive human lower molars.

A^1, crown view; A^2, inner side; A^3, outer side.

Fifth, the posterointernal angle of the upper molars developed a posterior swelling, the hypocone or distolingual cusp, which overlapped the trigonid, or anterior moiety of the corresponding lower molar.

Sixth, the inner bud or protocone of the upper molar meanwhile became larger and in articulation filled the expanding basin, or central fossa, of the lower molar (*fig. 22-2*).

Seventh, a small postero-median cusp of the lower molars, the distal cusp or hypoconulid, which first appears in some of the very early primates of the Eocene epoch, became enlarged and gave rise to the "fifth cusp" of primitive anthropoid lower molars (*fig. 23*).

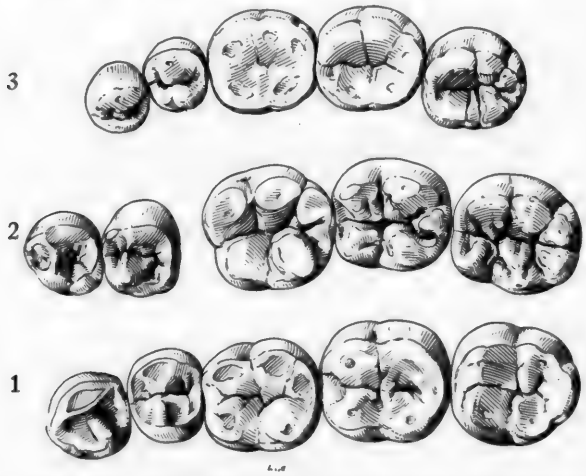

FIG. 24. Comparative series: right lower premolar-molar series of primitive men. × 3/2. *1, Homo heidelbergensis.* From a photograph published by Schoetensack. *2, Homo sapiens.* Molars of an old female Australian black. Premolars of a male negro. *3, Homo sapiens.* Lower premolar-molar series of a Strandlooper Bushman.

Eighth, between the five main cusps of the lower molars deep sulci developed, which, together with the five main cusps, gave rise to the "*Dryopithecus* pattern;" this pattern, which is seen in its fullest development in the Miocene anthropoid *Dryopithecus*, has been traced through many slight modifications into the diverse molar patterns of modern anthropoids and even of man, whose lower and upper molars bear the indubitable stamp of his lowly origin (*fig. 24*).

Ninth, the final changes in the purely human stage, associated with

IX Modern Man. Face and lower jaw largely retracted beneath the forwardly-grown and expanded brain case. Dentition and jaws reduced.

VIII Chimpanzee. Recent. Representing an advanced primate stage in which the face and lower jaw are partly retracted beneath the eyes. Brain case moderately expanded. Eyes looking forward, as in man.

VII *Notharctus*. Eocene, North America. Representing a very primitive stage in the evolution of the primate skull. A *secondary* contact between postorbital process of frontal and the zygomatic arch. Brain case small. Face not deflected downward beneath brain case. Eyes look chiefly outward.

VI *Opossum*. Recent America. Representing the most generalized type of mammalian skull. Temporal fossa and zygomatic arch completely mammalian. Postorbital bone lost. Dentary with new or mammalian joint between mandible and zygomatic arch.

V *Ictidopsis*. Triassic, South Africa. Near to the immediate ancestors of the mammals. Further development of the temporal fossa and zygomatic arch. Retention of the postorbital bone. Lower jaw very mammal-like, with large ascending ramus. Posterior jaw elements reduced. Dentition differentiated.

IV *Scymnognathus*. From the Permian of South Africa. Temporal opening enlarged. Zygomatic arch formed of same elements as in mammals.

III *Mycterosaurus*. From the Permian of Texas. A perforation appears in the middle of the temporal region, illustrating an early stage in the formation of the temporal fossa and zygomatic arch.

II *Captorhinus*. From the Permian of Texas. Essentially the same as Stage I but auditory notch obliterated, the temporal region being completely covered by derm bones.

I *Seymouria*. From the Permian of Texas. Representing a very early land-living stage. Brain case completely masked with dermal bones, which are homologous with those of the lobe-finned fishes. Region of middle ear covered by membrane only (auditory notch at posterior end of skull). Temporal muscles covered by dermal bones of temporal roof. Teeth homodont. Primary lower jaw completely ensheathed by derm bones, of which the dentary bone forms the main dentigerous element.

FIG. 25. Successive "Basic Patents" in the Evolution of the Human Jaws and Dentition.

the great expansion of the braincase, retraction of the jaws and widening of the space for the tongue, consisted chiefly in the reduction in size of the canines and anterior premolars, the rotation of the lower premolar crowns from a more anteroposterior to a more transverse position, the tendency to delay the eruption of the third upper and lower molars, to reduce the size of all teeth, and to replace the "*Dryopithecus* pattern" of the lower molars by a cruciform or +-shaped pattern of the more highly civilized races.

These stages are far from being speculative or hypothetical, but have been revealed through the examination and comparison of the dentition of recent and fossil anthropoid apes and man.

Thus we come to the end of this necessarily inadequate review of the principal stages in the evolution of the human dentition (*fig. 25*).

THE INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

A Brief Outline of Its Organization and Early Development

WILLIAM J. GIES, F.A.C.D.

Editorial Office, Journal of Dental Research

During the earlier years of his active endeavors in the field of dental research, the writer was impressed by the general indifference toward original investigation in stomatology that then prevailed not only among dental and medical practitioners, but also among the teachers of biology, of medicine, and of dentistry. The need for effectual agencies for widely concerted promotion of research in dental science and art, analogous to those in medicine and the medical sciences, gradually became so obvious that in the spring of 1917 he inaugurated a definite plan for the more rapid advancement of dental research by three important conventional means; namely, a journal, an international asssociation, and improvement of the status and of the support of research in the dental schools and universities.

During the progress of the preliminary effort to establish the *Journal of Dental Research* (1917–1919), which was the first of the three agencies to receive direct attention, an endeavor to found an international association was initiated. Believing that such an association could best be formed as a federation of local societies, each to be in effect an autonomous section of a national division of the international organization, and confident that it could be projected effectually in the largest city in the United States, the writer corresponded or conferred orally with about one hundred of the leading dentists in New York regarding the feasibility of the general plan and the personnel of the charter membership. Occasional private ballots during a period of about two years (1919–1920) having clearly crystallized opinion, the men who had been selected by this democratic procedure were invited to dine at the Columbia University Club, at 4 West 43rd Street, New York City, on the evening of Decem-

ber 10, 1920, to consider the advisability of promoting research by international organization. The names of those who attended the dinner are appended:

E. A. Bogue
Adolph Berger
Theodor Blum
George W. Clapp
Henry S. Dunning
William J. Gies
Henry W. Gillett
R. G. Hutchinson, Jr.
Thaddeus P. Hyatt
Milo Hellman
Victor H. Jackson
F. C. Kemple
Arthur H. Merritt
Bissell B. Palmer, Jr.
Frederick A. Peeso
M. L. Rhein
James P. Ruyl
Paul R. Stillman
L. M. Waugh
J. Leon Williams
J. Lowe Young

Drs. Herman E. S. Chayes, William B. Dunning, M. I. Schamberg, and Frank T. Van Woert were unavoidably prevented from being present, but had indicated complete accord with the tentative plan for the organization of the proposed Association.

After the conference had been organized by the selection of J. Leon Williams as Chairman, and of L. M. Waugh as Secretary, the writer formally outlined the steps that led to the meeting, and included a statement to the effect that dentists in Boston and Chicago, who had been consulted, were ready to endorse the general proposal and to hold meetings promptly for the organization of sections. An earnest approbative discussion eventuated in a unanimous vote to organize the proposed association by the adoption of the following Articles of Agreement, which previously had also been submitted to and informally approved by the earliest of the prospective members in Boston and Chicago.

ARTICLES OF AGREEMENT

EFFECTING THE ORGANIZATION AND PROVISIONAL GOVERNMENT OF THE INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

Founded in New York City, December 10, 1920

PREAMBLE

In order to promote broadly the advancement of active research in all branches of dentistry, and in related phases of the arts and sciences that contribute directly to the development of dentistry; and, further, to en-

courage and facilitate coöperative effort and achievement by, and mutual helpfulness among, investigators in all nations in every division of stomatology—to the end that dentistry may render cumulatively more perfect service to humanity—we, the undersigned, assembled at the Columbia University Club, in New York City, December 10, 1920, hereby establish the International Association for Dental Research, and, as its founders, subscribe to and adopt these Articles of Agreement for the provisional government of this Association.

Article I. Officials

Section 1. *Provisional government.* The provisional executive management of this Association shall be vested in a Council of eleven members, at least six of whom shall be elected at this meeting of organization.

Section 2. *Officers.* The officers of the Council, to be elected by the Council itself, shall serve as the officers of the provisional government of this Association.

Article II. Instructions to the Council

Section 1. *Preparation of a Constitution.* The Council to be elected is hereby instructed to prepare a Constitution for our permanent government, to replace these Articles, and to submit to us such a Constitution for formal consideration before February 1, 1921. The Council is also charged to consider ways and means for the permanent international establishment of this Association, and for the immediate progressive furtherance of the Association's purposes. The Secretary of the meeting at which these Articles are adopted shall transmit a copy of these Articles to each member of the Council to be elected.

Section 2. *Meetings of the Council.* The Council may, by a majority vote of its total membership, call meetings of the Council after December 18, 1920; and, by such a vote, the Council may use any means at its discretion for prompt procedure toward attainment of the objects of this Association.

Article III. Meetings

Section 1. *Next meeting.* The next meeting of the Association shall be held at the Harvard University Club, on December 17, 1920, when three additional members of the Council may be elected.

Section 2. Meetings of the Association may be called by the Council on its own initiative, and shall be called at the request of five members of the Association.

ARTICLE IV. ABSENT COLLEAGUES ELECTED TO CHARTER MEMBERSHIP

Having indicated direct interest in the successful foundation of this Association, but having been unavoidably prevented from attending this meeting of organization, those of our colleagues who are named below, in this Article, are hereby unanimously elected to membership as founders of this Association:

New York: Herman E. S. Chayes, William B. Dunning, M. I. Schamberg, F. T. Van Woert.

Boston: Robert R. Andrews, Lawrence W. Baker, George A. Bates, Fred R. Blumenthal, Percy R. Howe, A. Leroy Johnson, V. H. Kazanjian, L. M. S. Miner, William Rice, Alfred P. Rogers, H. Carlton Smith, Eugene H. Smith, Kurt H. Thoma, George H. Wright.

Chicago: Frederick B. Noyes.

ARTICLE V. SECTIONS OF THE ASSOCIATION

The members in any geographical group may organize local sections of this Association; but they may not do so prior to the adoption of a Constitution that will prescribe the relationships of such sections to the Association in general.

ARTICLE VI. NEW MEMBERS

Pending the adoption of a Constitution to replace these Articles of Agreement, new members may be elected by a majority vote of the members in any geographical section, subject to confirmation by a majority vote of the total membership of the Council.

ARTICLE VII. QUORUM

Nine members shall constitute a quorum for the transaction of business by this Association until these Articles of Agreement for our *provisional* government will have been superseded by a Constitution, for our *permanent* government, adopted in conformity with these Articles.

(Signed by all named above as present at the meeting of organization.)
Attest:

J. LEON WILLIAMS, *Chairman.* L. M. WAUGH, *Secretary.*

On December 17, 1920, Dr. J. Leon Williams and the writer attended the second meeting of the Association, at the Harvard Club in

Boston, where the Boston members named in the foregoing Articles of Agreement laid the foundation for the Boston Section, and additional members of the Association, chiefly resident in Boston and Chicago, were elected. On December 30, 1920, the writer presented the plan to the Chicago members and their guests, who then took the preliminary steps for the establishment of the Chicago Section.

In accordance with the requirements of the foregoing Articles of Agreement, the Council was organized promptly by representatives of the New York, Boston, and Chicago groups, and by the spring of 1921 the appended Constitution, prepared by the Council, had been adopted for the government of the Association.

[*General informal memorandum.*—The following Constitution created an international body composed of national (general) divisions containing intranational (local) sections. The divisions and sections are autonomous in accordance with the limitations of ordinary federation. Article II states the objects, which include the primary purpose to provide meetings for the encouragement and assistance of those actually engaged in research. Members, who are elected by the Association at annual meetings only, may organize divisions in any nation and sections in any division. Anyone who has conducted and published an account of a meritorious original investigation in dental science or art, or in any of the sciences contributory to stomatology, is eligible to membership. A Council of representatives of the present Sections serves as an executive committee during the intervals between annual meetings, which are devoted primarily to the presentation and discussion of papers on research by the members and their guests. Article III prohibits commercial relationships between the Association and individuals or organizations. By-laws have not yet been adopted.]

CONSTITUTION OF THE INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH

ADOPTED IN CONFORMITY WITH THE PROVISIONS OF THE *Articles of Agreement* ON WHICH THE INTERNATIONAL ASSOCIATION FOR DENTAL RESEARCH WAS FOUNDED IN NEW YORK CITY ON DECEMBER 10, 1920, AND WHICH ARTICLES OF AGREEMENT THIS CONSTITUTION SUPERSEDES AND REPLACES

ARTICLE I. NAME

This organization is named: *International Association for Dental Research.*

ARTICLE II. OBJECT

The Association has been established (a) to promote broadly the advancement of active research in all branches of dental science and in related phases of the sciences that contribute directly to the development of

dentistry, and which add to the knowledge of the mouth and teeth and of their relations to the body as a whole; and, further, (b) to encourage and facilitate coöperative effort and achievement by, and mutual helpfulness among, investigators in all nations in every division of stomatology; (c) to the end, particularly, that dentistry may render cumulatively more perfect service to humanity.

Article III. Prohibition of Commercial Relationships

This Association shall in no way enter into, or foster, relations with commercial organizations, nor with makers of appliances or of anything else used in the art of dentistry by the dental profession, or in the care and treatment of the oral structures by the laity.

Article IV. Membership

Section 1. *Eligibility.* Any person who has conducted, and published an account of, a meritorious original investigation in dental science, or in any of the sciences contributory to stomatology, shall be eligible to membership in this Association, providing such person conforms to the recognized standards of professional ethics.

Section 2. *Nomination.* (A) Nominations to membership may be made at any time by any member. Each nomination must be formally endorsed by two additional members, who know personally and certify from specific knowledge, that the candidate for membership is eligible, before the nomination can be registered for official presentation to the Association.

(B) Each endorsed nomination for membership must be formally presented to the Council of the Association, with three copies each of one or more publications which show that the nominee meets the requirement of eligibility relating to research achievement.

(C) The Council shall determine, in the case of each nomination, whether the nominee fully meets the requirements of eligibility. The Council shall report promptly to the Association the details of its findings in this relation, and also such recommendations as it may wish to offer with its report.

Section 3. *Election.* (A) New members may be elected only at annual meetings of the Association.

(B) Election to membership shall be by ballot by the *individual* members. A two-thirds affirmative vote of the ballots cast shall be necessary for election. Substitution of any other parliamentary procedure for that

of a secret ballot shall invalidate all elections to membership that may be accomplished in such an irregular way.

SECTION 4. *Initiation.* Initiation of membership in this Association requires (a) formal approval of a certified copy of this Constitution, signified to the Secretary of the Council; also (b) the member-elect's formally avowed acceptance of, and adherence to, all the provisions of this Constitution and of the by-laws of the Association. No member-elect can exercise the privilege of membership before these requirements are met.

SECTION 5. *Forfeiture.* Membership in this Association may be terminated by a member at any time by formal notice, to the Secretary of the Council, of that member's withdrawal. Delivery of such a notice automatically effects that member's withdrawal from membership in this Association.

The privilege and rights of membership may be terminated by the Association for any member at any time, by formal notice to a member, from the Secretary of the Council, of the Association's decision, at an annual meeting by a two-thirds vote of those present and voting, that the member's association is no longer desired. Delivery of such a notice to a member automatically terminates his or her membership in this Association.

Annual dues for the fiscal year in which membership may be terminated by a member or by the Association, shall be repaid or, if unpaid, shall not be demanded.

ARTICLE V. DIVISIONS OF THE ASSOCIATION

SECTION 1. *Organization.* The members in any nation, with the approval of the Association, may organize a Division of the Association, particularly for the national advancement of the objects of the Association.

SECTION 2. *Management.* The national affairs of a Division shall be managed by its own members, but such management must conform in all respects with the requirements of this Constitution and of the by-laws of the Association.

ARTICLE VI. SECTIONS OF THE ASSOCIATION

SECTION 1. *Organization.* The members in any geographical center may organize a Section of the Association with the approval of the corresponding National Division, particularly for the local advancement of the objects of the Association.

SECTION 2. *Management.* The affairs of the Sections shall be managed by their own members, but such management must conform in all respects with the requirements of this Constitution, with the by-laws of the

Association, and with the by-laws of the corresponding national Division of the Association.

Article VII. Meetings

Section 1. *Annual.* The Association shall meet at least once annually, beginning with the calendar year 1921, at times and places to be determined by the Association, or by the Council when it is authorized to act for the Association.

Section 2. *Special.* Special meetings of the Association may be convened by the Council, and shall be called at the request of one-fifth of the total membership.

Article VIII. Officials

Section 1. *Council.* (A) Authority. During the periods between annual meetings, the executive management of the affairs of the Association shall be conducted by the Council, within the general authority voted to it by the Association.

(B) Personnel. (a) The Council shall consist of three elected representatives of each national Division. Until the number of divisional representatives in the Council attains a total of at least fifteen, the number necessary to constitute that total shall be elected from the American Division of the Association.

(b) With the adoption of this Constitution, the terms of all the members of the existing Council of the Association (selected on the basis of the provisional organization) shall close automatically, when it shall become the duty of each of the three existing and ratifying Sections of the Association to elect by ballot five Councillors, the fifteen Councillors thus elected to serve as, and to be, the Council of the Association, until their successors will have been chosen in accordance with the provisions of this Constitution.

(C) Election of the divisional representatives. The representatives of the national Divisions in the Council shall be elected by the respective national Divisions.

(D) Length of the term of service. The length of the term of service of the individual representatives in the Council shall be determined by the respective national Divisions.

Section 2. *Officers.* (A) Identical with those of the Council. The general officers of the Council shall be, also, the officers of the Association. They shall be nominated by the Council, preferably though not necessarily from its own membership, subject to formal confirmation by the Association.

(B) Nomination. The list of nominations for the offices of the Council and Association, for a given term, shall be formally announced by the Council to each member of the Association at least three months prior to the date of the annual meeting at which the same nominations will be presented to the Association for its consideration.

(C) Election. The Council's nominees for the offices in the Council and Association, if approved by a majority vote of those present and voting at the succeeding annual meeting, shall become the officers of the Council and of the Association. In the event, however, that the Association should record a majority vote against any of the Council's nominees for the general offices, the Council shall present one or more additional nominations for the corresponding offices at the same meeting, until the Association votes its approval; but should the Council fail to make satisfactory nominations, the Association may then and there, independently of the Council, complete the nomination and election of general officers of the Council and Association.

(D) Elective term of service. The elective term of service in all the general offices of the Council and Association shall begin at the close of an annual meeting and shall terminate at the end of the next succeeding annual meeting.

Article IX. Finances

Section 1. *Amount of dues.* The annual dues, payable by each member, before the close of each annual meeting of the Association, shall *not exceed* five dollars ($5.00) or its approximate equivalent.

Section 2. *Payment of dues.* The annual dues may be paid through the agency of national Divisions.

Section 3. *Restriction on the expenditure of funds.* No funds of the Association may be expended by the Council without general authorization by, or approval of, the Association.

Article X. By-Laws

By-laws of this Association may be adopted at any meeting of the Association by a two-thirds vote of the members present and voting.

Article XI. Quorum

Fifteen members shall constitute a quorum of this Association.

ARTICLE XII. AMENDMENTS

SECTION 1. *Constitution.* (A) Presentation. Proposed amendments to this Constitution may be presented, at annual meetings of the Association, by and with the formal endorsement of five members. Statements of reasons for the adoption of proposed amendments must accompany the formal presentation of each such amendment.

(B) Notification to all the members. It shall be one of the duties of the Council to deliver to each member of the Association, within six months of the date of the annual meeting at which it was proposed, or will be considered, (a) a printed copy of each such suggested amendment, with the names of the sponsors and the reasons given formally for its proposed adoption; also (b) a blank ballot for the registration of a vote for or against the proposed amendment.

(C) Adoption. At the next, or any, succeeding annual meeting, the foregoing conditions having been met in detail, a vote on the proposed amendment shall be in order; and the proposed amendment shall become a part of this Constitution if, and when, at least two-thirds of the entire membership of the Association vote for its adoption.

SECTION 2. *By-laws.* Amendments to the By-laws may be adopted at any meeting of the Association by a two-thirds vote of those present and voting.

[By-laws have not yet been adopted]

Ratified for the Association, by the New York, Boston and Chicago sections, on May 27, 1921.

Attest:

J. Leon Williams, *President.* L. M. Waugh, *Secretary.*

Since the adoption of the foregoing Constitution, which is still in force, sections of the Association have been organized in Toronto (1921), Ann Arbor (1923), and San Francisco (1924), and successful annual meetings have been held in New York and Chicago. Accounts of the past proceedings of the several sections and of the annual meetings of the Association, by the secretaries of the Sections and of the Association, will be included in early issues of the *Journal of Dental Research.* The regular presentation in this *Journal*, hereafter, of the scientific proceedings of the Association and of its divisions and sections, promises to further the cumulative general development of dental research as effectually as the similar publication of the

Proceedings of the Society for Experimental Biology and Medicine has activated medical research in America since 1904.

The Association was organized to promote research, nothing else; and is wholly impersonal in character and avowedly non-political in purpose.[1] Its development has been slow but spontaneous; and its activities, however restricted, have been natural not artificial. It has not been forced to walk before it was able to stand. Although the Association has not been much stronger than the slowly developing spirit of research in the dental profession, and has shown unmistakable symptoms of recurrent rickets, nevertheless the food which dental research is now receiving is better balanced and more nutritious than it has been. A further improvement of the present diet, which contains increasing proportions of the vitamins of financial sustenance, will cause more rapid growth of dental research, and will also assure the Association's attainment of health, vigor, activity, and fecundity. It is hoped that additional sections will be organized in this country and Canada, and abroad.

The first published reference to the International Association for Dental Research was appended to an appreciation of Robert R. Andrews by George A. Bates,[2] both of whom attended the meeting for the organization of the Boston Section, and spoke earnestly in behalf of international accord for the advancement of dental research. Andrews and Bates, distinguished for high character as men and dentists and teachers, exemplified, in their devotion to idealism and scholarship and truth, the spirit and the abiding aspirations of the International Association for Dental Research.

[1] Williams: *Journal of Dental Research*, 1923, v, p. 27.
[2] Editorial comment: *Journal of Dental Research*, 1921, iii, p. 5 (footnote).

THE DENTO-ENAMEL CIRCULATION[1]

CHARLES F. BÖDECKER, D.D.S., F.A.C.D.

New York City

The age in which we considered the teeth to have no connection whatever with the rest of the body is passing. Many, however, still cling to the old idea that the work of the dentist requires only mechanical skill for repair and that the teeth bear no relation to the other tissues of the body. My father, however, early instilled in me the idea that the teeth serve as an index to the state of health of the patient, being intimately associated with the other organs. It has been the aim of my work, during the past eighteen years, to establish this fact upon a scientific basis. The first step, in fulfilling this plan, was to prove the existence of organic matter in both the dentin and enamel, sufficient to carry circulatory fluids through these tissues; the second, to demonstrate the existence of channels passing from the pulp chamber through the dentin, across the dento-enamel junction into the enamel.

The dentin has admittedly a large percentage of organic matter in its tubuli and basis substance which offers many channels for a circulatory fluid; the proof, however, of the existence of organic matter in the enamel, has been far more difficult. The reason for this is that the microscopic-technical methods of study of this tissue had been insufficiently developed, and it was only by devising new ones that progress could be made in this direction. The photomicrographs I shall show you were made from specimens treated by my celloidin decalcifying method and conclusively prove the existence of an ample amount of organic matter in the human adult enamel of the teeth, sufficient to sustain a circulation in this tissue. By means of speci-

[1] Read at a meeting of the International Association for Dental Research, at the Columbia University Club, New York City, December 21, 1922.

Five additional related papers have been received for publication in the succeeding issue.

mens shown under the microscope, I hope to convince you of the presence of this organic matter as well as of the existence of a circulation. Having once proven this to be true, the possibility of a change taking place in the hardness of the enamel is demonstrated. Pickerill's work[2] furnishes sufficient evidence of the existence of malacotic and sclerotic teeth, contrary to the assumption of others who claim that enamel does not vary in hardness and once formed can not change in density. It would, however, lead me too far from my subject to go into this question in detail.

The enamel is usually designated as a structure rather than a tissue, but it is my belief that the word *tissue* should be applied to it also, in order to emphasize its analogy with the other tissues of the body. I may be somewhat previous in this claim, for the factors making up vitality have not all been proven to exist in enamel. I wish, therefore, to define my position on the subject of the vitality of the enamel and its variation in hardness.

(a) Enamel contains a far greater amount of organic matter than heretofore assumed.

(b) A circulation passing from the pulp through dentin and enamel is maintained under normal conditions.

(c) Clinical experience, especially that of the periodontist, who has occasion to remove parts of enamel from vital teeth, indicates the occurrence of sensation. No histological proof of the presence of nerve fibers is as yet forthcoming; nevertheless I admit the possibility of their existence even in the enamel.

(d) After the enamel-forming organ is destroyed through the eruption of the tooth, no change in the *form* of the enamel can take place.

(e) However, a change in the percentage of the inorganic salts, takes place in the enamel after the eruption of a tooth and during life, thus accounting for the variation in hardness at different periods.

(f) These inorganic salts, I believe, are carried in solution from the interior of the tooth outwards, by the above mentioned channels and not deposited by the saliva from the surface.

The dentin is admitted to have a circulation. Its innumerable

[2] Pickerill, H. P. Dental Caries, 1912. Baillière, Tindall and Cox, London.

tubuli filled with Tomes fibers form the connecting link between the pulp and the surface of the dentin. In 1912,[3] I first called attention to the fact that Tomes fiber was not a fiber but had the shape of a tube and, as such, furnished an ideal channel for the afferent circulatory fluid. The return current runs through the space bounded by the sheath of Neumann, which has the function of limiting the walls of the tubuli for the passage of this fluid. Thus, over sixty years after the discovery of this sheath, its physiological significance was recognized.

The last point to be demonstrated is the connecting link between the circulatory fluid in the dentin and the organic matter in the enamel. For this purpose, ground sections will be shown under the microscope proving this connection. The slides were prepared in the following manner: The entire pulp of an incisor tooth of a calf was removed at the apex of the root and coloring matter forced into the canal. This stain, as will be seen in the ground section, has passed through the dentin and penetrated the enamel. At the dento-enamel junction, the observer can clearly see, in one field of observation, hundreds of fine tubuli crossing the border into the enamel and joining the so-called interprismatic substance. This designation, interprismatic substance of the enamel is obscure, as my work on this subject has shown that two different structures are included under this heading. Each enamel rod or prism is enclosed in a complete envelope and occasional spaces left between these are filled in with a cement-like substance. We see, therefore, that what has been called interprismatic or cement substance, is composed of two separate structures, namely, the enamel prism sheath and the interprismatic substance proper. Dr. Williams' excellent photomicrographs of ground enamel as well as mine of decalcified enamel clearly prove this assertion.

In conclusion, gentlemen, I wish to emphasize the fact that there is an afferent circulation in every normal tooth, passing from the pulp through the dentin into the enamel and a return current by the same path, back to the pulp chamber. In regarding the tooth structure

[3] Bödecker, C. F. Some recent investigations upon the histology of the dentine. *Dental Review*, 1912, xxvi, p. 260. The soft fiber of Tomes, a tubular structure, its relation to dental caries and the desensitization of dentine. *Journal of the National Dental Association*, 1922, ix, p. 281.

from this aspect, we marvel that nature allows us to make such deep ingressions with our fillings without causing any painful reaction. Some might regard this as proof that I am gauging the vitality of the dentin and enamel too high. My answer to this criticism is: examine the pulp chambers of a number of carious and filled teeth under the microscope and note the layers of secondary dentin. This deposit proves that the pulp has felt the irritation of fillings and approaching caries and tried to shield itself in this manner. Further I wish to emphasize that the enamel rod sheaths are in connection with the tubuli of the dentin, thus forming the end organs of the dento-enamel circulation.

(Microscopic demonstrations followed, and photomicrographs were shown. The most significant of these will appear in papers in the succeeding number.)

ADDENDUM

The organization of the International Association of Dental Research denotes an immense stride in the developement of our profession, for such a representative body of scientifically trained men will be in a position to corroborate or refute new theories. The paper brought before you tonight is a synopsis of some of my work and although my first efforts date back eighteen years, I have received neither rebuttal or corroboration. The methods of research have been, up to now, too individual, there has not been sufficient concerted action. A parallel case would be the following: a retiring treasurer delivers his report which is checked by two members of the society. In the same manner, I consider it only just to check new theories, in order to accept or discard them. This, gentlemen, is the action I beg a committee of the International Association for Dental Research to take upon my work.

576 Fifth Avenue.